Coastal Management Study

Safety Bay/Shoalwater Coastal Management Study

CW1082000

Prepared for
City of Rockingham

17 December 2019

Cardno

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1 Introduction

1.1 Study Area

The City of Rockingham is situated approximately 38km south-southwest of Perth's central business district in Western Australia. With over 37km of Indian Ocean coastline, the City's identity, prosperity and lifestyle is underpinned by the variety of recreation, conservation, tourism and commercial activities provided by the coast. Given the proximity of high value private and commercial infrastructure to the shoreline and the inherent value provided by the coast itself, natural variability in sea level and coastal processes in the region, as well as potential changes associated with a changing climate, pose management challenges for the City.

The study area is nested toward the north of the City's boundary and comprises sections of the Cape Peron, Shoalwater and Safety Bay shorelines (**Figure 1-1**). Fringing the Shoalwater Islands Marine Park and confined by a series of offshore reef platforms, islands and dynamic sand bars, the sustainable provision of coastal infrastructure within the study area is subject to challenging technical, financial, environmental and social constraints.

1.2 Study Purpose

The purpose of this study is to develop a strategic approach to coastal management for the next 10 years, with staging for the near term (1-3 years) and medium term (4-10 years), with due consideration of coastal processes over the next 30 years. The study aims to draw on the following aspects applicable to the study area's coastline:

> Natural coastal processes and climate change sensitivity;

> Interaction with existing management activities;

> Impact on asset performance, natural resources values and future demand;

> Existing, alternative and innovative coastal management strategies and their effectiveness;

> Desires and preferences of stakeholders; and

> Technical feasibility, financial viability, and environmental and social acceptability.

1.3 Definitions

Table 1-1 Definitions

Term	Definition
Bathymetry	The study and mapping of the sea floor, including depth and features characteristics.
Littoral drift	The transport of non-cohesive sediments, i.e. mainly sand, along the foreshore and the shoreface due to the action of the breaking waves and currents parallel to the shore.
Navigation channel	A passage in a stretch of water where the seabed is deep enough to enable the safe movement of boats.
Offshore sand feed	An elongated nearshore sand feature that provide a supply of sand to the shoreline. It is characterised by a raised profile above the surrounding seabed, which can be attributed to the local reworking of sediments by converging bottom currents (e.g. tidal asymmetry or wave focusing).
Sediment budget	The balance between sediment added to and removed from a sediment cell. The budget account for sediment supply (sources), loss (sinks), and the flow between sources and sinks (pathways).
Sediment cell	A spatially discrete areas of the coast within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange, often described using sediment budgets.
Tombolo	A causeway-like accretion spit that connects an offshore rock or island to the main shore, or to another island.
Diurnal tide	A tidal pattern characterised by one high water (tide) and one low water (tide) per day.

N

0 375 750 Meters

1:30,000 Scale at A3

Study Area

FIGURE 1-1

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Date: 2019-11-25
Coordinate System: GDA 1994 MGA Zone 50
Project: CW106600_001
Map: Figure 1-1_Study Area.mxd 01
Image source: nearmmaps.com (October 2019)

1.5 Coastal Processes

1.5.1 Nearshore Bathymetry

The nearshore bathymetry of the study area is characterised by a series of offshore reefs running parallel to the shoreline. The closest of which are known as the Murray Reefs, which comprise the exposed Shoalwater Islands as well as submerged and partially submerged limestone platforms extending from Garden Island to the south of Warnbro Sound. Approximately 8km further offshore is another ridge of reefs known as Five Fathom Bank. The offshore reef systems help to reduce wave energy at the study area's shoreline.

1.5.2 Climate and Metocean Conditions

1.5.2.1 Wind

The study area is influenced by two dominant seasonal weather patterns. The summer period is generally characterised by the sea breeze cycle with easterly winds in the morning shifting to south-westerly sea breezes that generally increase through the afternoon. The winter period is generally characterised by intermittent storms attributed to mid-latitude low pressure systems, bringing more west to north-westerly wind conditions.

1.5.2.2 Waves

The local wave climate is dominated by two main seasonal patterns:

- During summer, the wave conditions are generally calm but they can be interrupted by local wind generated short period waves propagating from the south, south-west; and
- During winter, synoptic storms lead to higher energy wave conditions and a greater presence of longer period waves generated off-shore and generally propagating from the southwest.

Tropical cyclones that develop during the summer months off WA's north-west coast rarely track down to the study area's latitude, but have been recorded in the region.

1.5.2.3 Water Levels

The astronomical tide regime in the study area is predominantly diurnal, characterised by one high water and one low water per day. The typical tidal range is approximately 0.4 m but can get as high as 1.2 m during peak spring tides. Water level data covering varying timeframes is available from 1986 at Fremantle Fishing Boat Harbour, Mangles Bay, Warnbro Sound and Mandurah.

The effects of barometric pressure changes, wind fetch, wave set-up and climate change can result in water levels to rise above the astronomical tide. In coastal engineering, the resultant increase in water levels is commonly referred to as the extreme water level and is a governing factor in the planning, management and design of coastal infrastructure. Extreme water levels at the study area are lower for the section of coastline east of Cape Peron. This is largely attributed to the reduction in wave energy and thus wave set-up on the section of north fronting coastline.

1.5.2.4 Climate Change

Globally, mean sea level has risen since the nineteenth century and is predicted to continue to rise, at an increasing rate, through the twenty first century. This is expected to bring changes to the Western Australian coastline over the coming decades. To prepare for sea level rise induced coastal hazards, such as more frequent coastal erosion and inundation, all levels of government are putting processes in place to ensure that communities understand the risks to values and assets on the coast, and to plan to adapt over time.

Changes to mean sea level over the past century have been observed for the coastline adjacent to the Perth Metropolitan Area. *Sea Level Change in Western Australia – Application to Coastal Planning* (Department of Transport [DoT], 2010) reviewed information relating to Sea level rise at a local scale and recommended an allowance be adopted for planning purposes. The West Australian State Government revised the State Coastal Planning Policy in 2013 to incorporate a projected sea level rise for WA of 0.9 m between 2010 and 2110.

1.5.3 Sediment Dynamics

The study area is subject to complex coastal processes, which is highlighted by the relatively high number of tertiary sediment cells over a short spatial span. Sediment cells are spatially discrete areas of the coast, within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange. These exchanges are often described as sediment budgets. Swell waves generated offshore of the study area diffract around the outer reefs and islands, resulting in the formation of low energy wave pockets and subsequently accretion of the shoreline. Most noticeably, this phenomenon has led to the accretion of the shoreline in the lee of Bird Island, Seal Island, Penguin Island and First, Second and Third Rocks. Simultaneously, several sections of coastline within the study area have been subject to erosion at seasonal, interannual and interdecadal timeframes. There are a number of very dynamic coastal features contained within the study area, including Mersey Point and Tern Bank Sandbar. The future of such features is not particularly well understood due to their reliance on the presence and dynamics of offshore sand feeds.

1.5.4 Engineered Structures

The study area has been extensively modified via numerous coastal structures, including groynes, jetties, seawalls and boat ramps. The presence of these structures has an important influence on local sediment transport patterns and nearshore hydrodynamics, to varying degrees over time. A depiction of coastal structures within the study area is provided in **Figure 1-2**.

1.6 Boating Facilities

Boating within the waters of the study area is abundant on a commercial and recreational level. Rockingham Wild Encounters operate ecotourism services within the Shoalwater Islands Marine Park which include a ferry service to and from Penguin Island and cruises to showcase the local marine life. Recreational boaters predominantly utilise the study area for snorkelling, diving and access to fishing spots. There is a water skiing and parasailing area within the Warnbro Sound which is often accessed by the boat launching facilities within the study area. Extensive cray fishing takes place in WA between latitude 24 degrees South and 34 degrees South, generally between November and June.

There are four boat launching facilities located within the extents of the study area. Point Peron Boat Launching Facility is located on the north of Cape Peron and comprises four concrete ramps and associated maritime infrastructure and amenities. Carlisle Street, Bent Street and Donald Drive boat ramps are located along Arcadia Drive on the Safety Bay foreshore. Bent Street Boat Ramp comprises two concrete ramps separated by a finger jetty and informal over-sand ramps on either side. Carlisle Street and Donald Drive are informal over-sand facilities which allow the launching of small vessels during favourable weather conditions.

The Department of Transport's (DoT) revised Perth Recreational Boating Facilities Study is scheduled for public release by the end of 2019. Preliminary liaison with DoT suggests that there is a need for additional recreational boating facilities south of the Swan River. Considering land use and catchment characteristics south of the Swan River, Rockingham is one of the few areas where the provision of the required recreational boating facilities is supported. Findings detailed in the 2008 Perth Recreational Boating Facilities Study which examined the recreational boating facility needs of the Perth metropolitan area to the year 2025 suggests that in excess of 10% of all registered boats in the Metropolitan area are located within Rockingham and additional facilities are needed to meet the projected demand in the City. Rockingham was found to have the second highest number of boat registrations by local government across the Perth metropolitan area. This number of registrations was anticipated to rise from 4,768 to 6,752 by 2025. Boat registrations within Rockingham comprise primarily of smaller, trailable vessels with 95% of registered boats being smaller than 7.5m in length, as compared to the 90% average for the Perth metropolitan area. The higher percentage of trailable vessels within Rockingham suggests that shortfalls in recreational boating facilities are centred around boat ramps and launching facilities, as opposed to moorings and pens which typically accommodate vessels greater than 7.5m in length.

Recommendations on the number of parking bays required for public boat ramps is provided in AS3962-2001 Guidelines for design of marinas. Compliance with the recommendations of AS3962 would require an additional 180 to 260 boat trailer parking bays for the ramps located within the study area. Deficiencies in boat

trailer parking are evident during peak periods by high volumes of overflow parking along the Arcadia Road reserve at Carlisle Street, Bent Street and Donald Drive. Overflow parking is particularly prominent during cray fishing season between November and June.

The provision of new developments to cater for shortfalls in both boat launching facilities and boat trailer parking within the study area are highly constrained by factors not limited to coastal processes, surrounding development, bathymetry, land tenure and environmental constraints. The summer sea breeze would likely result in the need for breakwater protection should a new facility be constructed along the Safety Bay foreshore. The natural bathymetry in Shoalwater Bay and Safety Bay is generally too shallow to allow statutory compliant launching and retrieval of vessels as well as allow safe navigation into deeper waters. The dynamic sediment transport processes result in a heightened risk of navigation channel sedimentation and increased sand management both upstream and downstream of protective structures such as breakwater arms. The fringing Shoalwater Island Marine Park and adjacent land use for most of the study area also adds complexities to the development of new facilities.

N

0 212.5 425 Meters

1:17,000 Scale at A3

Coastal Structures and Features

FIGURE 1-2

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Date: 2019-11-25
Coordinate System: GDA 1994 MGA Zone 50
Project: CW106600_001
Map: Figure 1-2_Coastal Feautures.mxd 01
Image source: nearmmaps.com (October 2019)

2 Strategic Coastal Management Methodology

The following subsections outline the strategic approach adopted to define coastal management options within the study area.

2.1 Literature Review

A literature review has been undertaken on the City's background documents, state and federal coastal management governance, and other background documents applicable to the study area. The literature review analysed data based on components which are likely to impact on the Coastal Management Study and established a solid foundation for the subsequent stages of the Study. The Literature Review is attached in **Appendix A**.

2.2 Stakeholder Consultation

A stakeholder consultation phase was carried out between the 2nd and 14th of August, 2019. Consultation was undertaken face to face with the DoT and Department of Biodiversity, Conservation and Attractions (DBCA) and via telephone for a number of secondary stakeholders including Commonwealth Scientific and Industrial Research Organisation (CSIRO), Western Australian Marine Science Institution (WAMSI), University of Western Australia (UWA), Curtin University, Murdoch University and Edith Cowan University (ECU) – School of Science. A summary of the stakeholder consultation findings is provided in **Appendix B**.

2.3 Sector Profiling

For the purpose of this study, the study area has been separated into six sectors. The sectors are shown in **Figure 2-1** and have been defined based on the sediment exchange connectivity which aligns with the sediment cell boundaries defined for the Vlamingh Coast (Stul et al, 2015). For each sector, site specific coastal management issues have been defined to inform the management study. Sector characteristics including land use, land tenure, coastal processes and social, recreational and environmental value have also been defined as part of the sector profiling phase.

2.4 Option Definition

A robust framework has been developed for the option definition process which captures the City's current coastal management activities along two dimensions; Asset type and phase of asset management. The asset type dimension details the built and natural coastal assets contained within the sector. The phase of asset management dimension details the life cycle phase of current and proposed management activities within the sector. Identification of the asset management phase can assist in providing an indication of appropriate sources of funding. An example of the option definition framework is provided in **Table 2-1** below. The framework enables visual identification of current management initiatives (referred herein as "status quo") and potential alternatives for future management which have been subsequently explored as strategic management options.

Table 2-1 Example – Option definition

Example – Option definition		Asset management stage							
		Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose
Assets	Seawall						1		
	Groyne				2				
	Jetty					3			

[1] Description of proposed upgrade works for Seawall. [2] Description of proposed monitoring plan for groyne. [3] Description of proposed new Jetty.

2.5 Multi-criteria Assessment

The ranking of the options defined previously for each sector, from the most preferred option to the least preferred option, has been established based on a multi-criteria assessment of the proposed options. The multi-criteria assessment is informed by three overarching themes (including technical feasibility, economic viability and environmental and social desirability), each of which contains criteria and a rating scale to guide the scoring of each option against each criterion as defined in **Table 2-2** below. As a result, each option is characterised by individual scores for each criterion and a total score.

The multi-criteria assessment framework adopted is proven to facilitate the appraisal of competing options in a transparent manner and enables the ability to work collaboratively with the City and other stakeholders during the option appraisal stage to ensure that the views of qualified professionals, local practitioners and coastal managers are considered in an inclusive way. The proposed framework underpins the strategic coastal management study.

A high-level cost breakdown for individual capital assets and operations is provided in the capital expenditure (CapEx) and operational expenditure (OpEx) rows of the multi-criteria assessment tables for each option considered. The high-level cost estimates are based on data provided by the City and reference to other relevant projects. The net present value (NPV) calculations are carried out up to 10 years only, in alignment with the Study's planning horizon. OpEx items scheduled after 10 year are not included. Some OpEx items are delayed due to the current capacity of the asset. For example, a newly built sand trap won't require clearing before its current capacity has been reached, however trigger or annual clearing would be required to stay on top of the accretion. The time lag included may vary depending on the type of asset and management operation being considered. Lag allowances are based on the average frequency of the City's coastal management operations. Coastal process variability may affect this allowance

Each sector has been assessed in the MCA relative to a baseline which is not comparable across sectors. As such, cross-sector comparisons are not intended. A real discount rate of 2.5% was considered in the Net Present Value calculation, as advised by the City.

Table 2-2 Multi-criteria assessment framework and metric scale

Theme	Criteria	Rating scale				
		1	2	3	4	5
Technical feasibility	Performance	Poor	…	…	…	Best in class
	Safety	Unsafe	…	…	…	Safe
Economic viability	Capital expenditure (CapEx)	Most expensive	…	…	…	Least expensive
	Operational expenditure (OpEx)	Most expensive	…	…	…	Least expensive
	Net present value (at the studies 10-year planning horizon)	High NPV	…	…	…	Low NPV
Environmental and social desirability	Impact	Unsustainable	…	…	…	Sustainable
	Regulation	Onerous	…	…	…	No approval required
	Public acceptance	Strong opposition	…	…	…	High support
	Independent operation from adjacent coastal managers	Coordination required	…	…	…	Independent

2.5.2 Sensitivity analysis

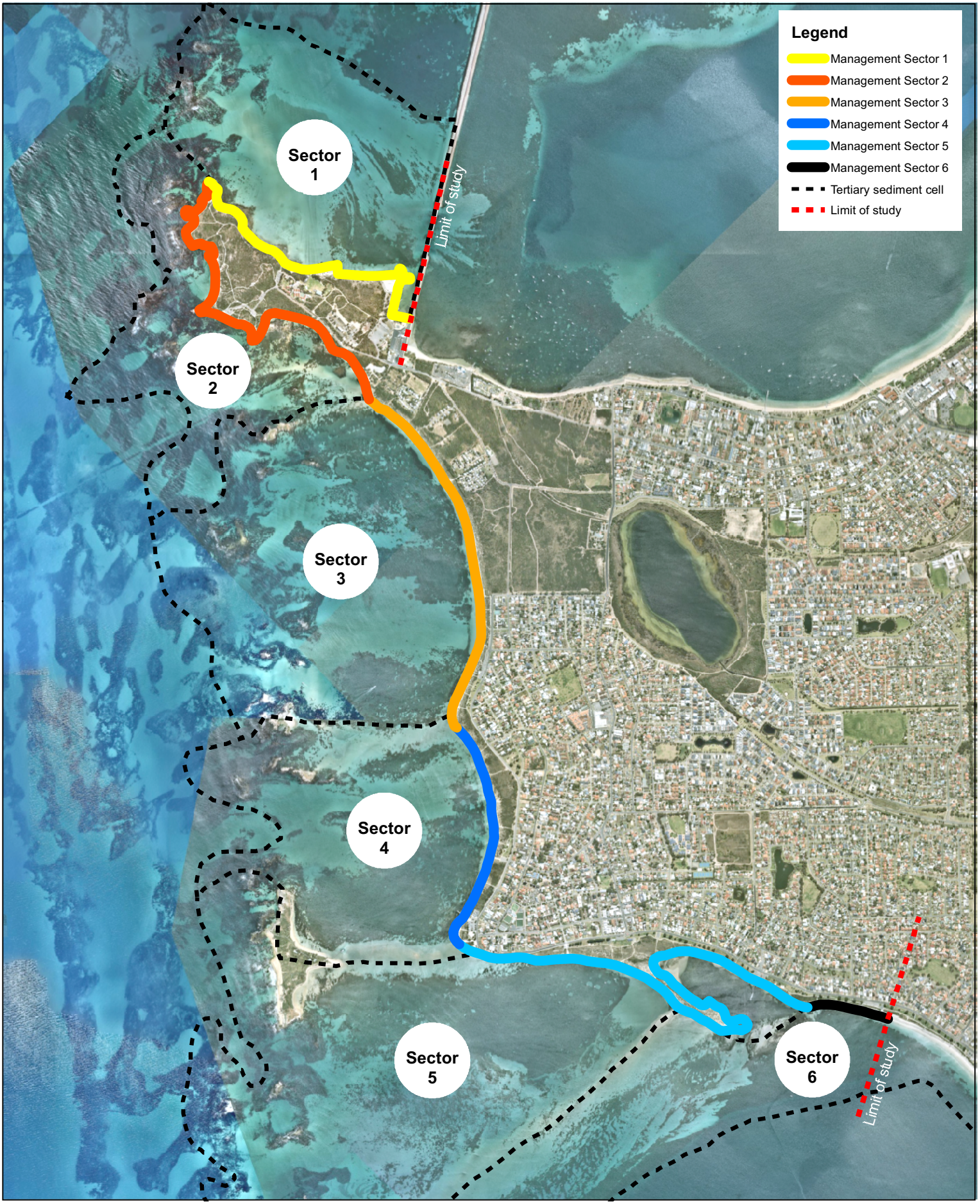
In the MCA framework, the total score for a given option results from the aggregation of each individual score for each criterion. Although weighting each criterion equally to calculate the option total score can provide an indicative ranking of the proposed options (i.e. from 1st ranked for the most preferred option to last ranked for the least preferred option), the total score may vary depending on the relative weight applied to each criterion. For example, some stakeholders may place more weight on CapEx than on Impact, while others may place more weight on Public Acceptance than OpEx, and so on. Thus, in order to account for such stakeholder

preferences ambiguity, a sensitivity analysis of the option ranking associated with the non-equal weight of each criteria has been performed using the numerical coding package R Studio.

A custom script was developed to simulate 100,000 simulations where stakeholders would randomly assign relative weights across the 9 criteria outlined in **Table 2-2** above. For each simulation, the weighted average total score was obtained for each option and the option rank (e.g. 1st, 2nd, 3rd) was derived. Subsequently a histogram of the rank distribution was produced for each option by counting how frequently the option was ranked 1st, 2nd, or 3rd.

By comparing the histogram for each option, it is possible to evaluate how likely an option is expected to be 1st ranked and how sensitive to stakeholder preferences this result might be. For example, a uniform histogram indicates that the option is equally likely to be ranked 1st, 2nd or 3rd. A bottom skewed histogram indicates that the option is more likely to be ranked as most preferred, while a bottom skewed histogram indicates that the option is more likely to be ranked as the least preferred.

The outcomes of the sensitivity analysis are reported on within subsequent sections. In general, it was found that differential weightings and the equal-weightings led to similar ranking. So, the most preferred option ranking result appears to be fairly robust and unlikely to be dominated by a single theme or criterion.



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0 250 500 Meters

1:20,000 Scale at A3

Coastal Management Sectors

FIGURE 2-1

Cardno

Date: 2019-11-25
Coordinate System: GDA 1994 MGA Zone 50
Project: CW106600_001
Map: Figure 2-1_Sectors 02.mxd 01
Image source: nearmmaps.com (October 2019)

3 Key Coastal Management Issues

Coastal management issues have been defined for the study area as a whole based on a desktop study and stakeholder consultation. The management issues are delineated further in subsequent sections based on issues specific to the respective management sectors. The study area wide key management issues have been incorporated as performance criteria throughout the multi-criteria analysis for proposed options and are detailed below:

- I01: Shoreline erosion – Loss of land
- I02: Shoreline erosion – Loss of infrastructure/ services
- I03: Siltation of dredged channels – Navigational safety
- I04: Siltation of dredged channels – Operational expenditure
- I05: Ageing assets – Safety
- I06: Ageing assets – Loss of functionality
- I07: Ageing assets – Capital expenditure
- I08: Ageing assets – Operational expenditure
- I09: Sand management – Extraction environmental impacts and approval processes
- I10: Sand management – Placement environmental impacts and approval process
- I11: Sand management – Placement acceptance (including discoloured material)
- I12: Sand management – Capacity exceedance and associated disposal options
- I13: Sand management – Impact on recreation, foreshore amenity and tourism
- I14: Coastal inundation – Loss of land
- I15: Coastal inundation – Loss of infrastructure/ services
- I16: Vessel interaction with fauna
- I17: Recreational boating capacity – Ramp infrastructure
- I18: Recreational boating capacity – Maritime structures
- I19: Recreational boating capacity – Carpark infrastructure
- I20: Coordination with coastal managers

4 Sector 1 – Cape Peron North

4.1 Sector Profile

Table 4-1 Profile – Sector 1: Cape Peron North

Attribute	Definition
Location	Sector 1 is bound by the Garden Island Causeway and the northernmost extent of Cape Peron. The shoreline of Sector 1 corresponds to Secondary Cell 15A for the Vlamingh Coast (Stul et al, 2015). The Sector is situated on Cape Peron, a predominantly rocky cape with sandy beaches fronting north, south and west.
Land use	Natural parks and recreation reserve, boating facilities, and public purpose lots comprising Point Peron Camp School and Point Peron Wastewater Treatment Plant.
Adaptive pathway (beyond 2030)	Long term managed retreat as per CHRMAP
Coastal processes	
Exposure	Low energy wave climate, sheltered from south-westerly Seabreeze by the Cape and offered protection to the north by Garden Island and offshore reefs. Calm conditions are maintained within Point Peron Boat Launching Facility by the Garden Island Causeway and Spur Groyne.
Sediment dynamics	Large offshore sand feed from Garden Island and inner reef platform. Net easterly alongshore drift leading to accrual of sand upstream of the Geotextile Sand Container (GSC) and Spur Groyne. The position of the Crystal Beach shoreline has historically fluctuated with the variance of the offshore sand feed from the exposed reef south of Garden Island. The Crystal Beach shoreline has generally been subject to a gradual trend of recession. With the exception of beach immediately upstream of the GSC and Spur Groynes, the shoreline between Crystal Beach and the Spur Groyne has shown a gradual trend of erosion since the Spur Groyne was constructed in 1995. The Point Peron Sand Stockpile area is subject to wind-blown sand issues.
Vulnerability to erosion	2030 erosion hazard line suggests shoreline recession of up to 80m within Sector. Infrastructure including the Point Peron Camp School and Point Peron Foreshore Carpark (NE) within extent of 2030 erosion hazard line. Refer CHRMAP for definition.
Vulnerability to inundation	Low lying land adjacent to Point Peron Boat Launching Facility susceptible to coastal inundation. Refer CHRMAP for definition.
Land tenure	
Shoreward	The Sector primarily comprises of three reserves vested within the City of Rockingham. Management responsibility is shared between the City of Rockingham, Department of Biodiversity, Conservation and Attractions and Water Corporation. Dominating the Sector is the Cape Peron Reserve (Reserve 48968), which is owned by the Western Australian Planning Commission and managed by the Department of Biodiversity, Conservation and Attractions. Situated to the east of the Sector is the Point Peron Boat Launching Facility Reserve (Reserve 3947) which is managed by the City of Rockingham. The Point Peron Waste Water Treatment Plant is also located within the Sector which is managed by the Water Corporation.
Seaward	The offshore water body is characterized by the Shoalwater Islands Marine Park General Use Zone which extends from the high-water mark toward Garden Island. The Point Peron Boat Launching Facility Reserve comprises a small area of offshore land which extends approximately to the tip of the Spur Groyne.
Social and recreational value	The Sector is primarily dominated by nature experience at Cape Peron and recreational boating via access at Point Peron Boat Launching Facility. Other key social and recreational value offered by the Sector include dog walking at North Point Peron Dog Beach, picnics, walking and hiking.
Environmental value	Fringing the Shoalwater Islands Marine Park General Use Zone, the Sector is a key area of environmental value. There is a low density of nearshore seagrass habitats, in comparison to other areas within the Marine Park. Offshore from the Sectors shoreline is Garden Island, a key foraging location for Little Penguin's to and from Penguin Island.

city of Rockingham
where the coast comes to life

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1:5,000 Scale at A3

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0 200

Sector 1 - Cape Peron North

FIGURE 4-1

Cardno

Map Produced by Cardno (WA) Pty Ltd
Date: 2019-12-12
Coordinate System: GDA 1994 MGA Zone 50
Project: CW1082000
Map: Figure 4-1_Sector 1 02.mxd 01
Imagery: Nearmaps.com (October 2019)

4.2 Key Management Issues

> S1-01 Loss of beach widths along artificially retained shoreline

> S1-02 Loss of Point Peron Camp School and Point Peron Foreshore Carpark (NE) infrastructure

> S1-03 Navigational safety implications associated with siltation of Point Peron Boat Launching Facility dredged channel

> S1-04 OpEx implications associated with siltation and the sand slug in lee of Spur Groyne

> S1-05 Safety implications associated with the ageing Spur Groyne

> S1-06 Functionality implications associated with the ageing Spur Groyne

> S1-07 CapEx implications associated with the ageing Spur Groyne

> S1-08 OpEx implications associated with the ageing Spur Groyne

> S1-09 Safety implications associated with the ageing GSC Groyne

> S1-10 Functionality implications associated with the ageing GSC Groyne

> S1-11 CapEx implications associated with the ageing GSC Groyne

> S1-12 OpEx implications associated with the ageing GSC Groyne

> S1-13 Approval process implications associated with extraction from the Sand Trap

> S1-14 Exceedance of Sand Trap capacity and subsequent sand disposal issues

> S1-15 Low lying land adjacent to Point Peron Boat Launching Facility susceptible to coastal inundation

> S1-16 Vessel and fauna collision due to high use boating zone coinciding with little penguin foraging route

> S1-17 Continual with Department of Biodiversity, Conservation and Attractions

4.3 Option Definition

4.3.1 Option 1 – Status quo

The status quo option incorporates the continual operation and maintenance of current assets within the Sector, including the Point Peron Boat Launching Facility, Sand Trap and Spur and GSC groynes. The status quo option also incorporates the planned upgrades of the Point Peron Boat Launching facility maritime structures and car park scheduled for 2020 and 2021 respectively, as well as the planned upgrades for the Spur Groyne scheduled for 2020. Current management within the sector which defines the status quo are detailed in **Table 4-2**.

Ongoing management of the Sand Trap has had an impact on the adjacent shoreline to the west, which is vested within the City of Rockingham but managed by the Department of Biodiversity, Conservation and Attractions. As a result, coastal management within the sector requires ongoing collaboration and coordination between multiple stakeholders and coastal managers.

Management of the Sand Trap and Point Peron Sand Stockpile pose ongoing challenges for the City. These challenges include the requirement to find a deposition site for excess stockpiled material prior to the next round of Sand Trap extraction. The material which is extracted and stockpiled is of suitable quality for the nourishment of beaches. Wind-blown sand from the Point Peron Sand Stockpile also poses issues for the City during certain wind conditions. Landfill disposal has occurred once from Point Peron Sand Stockpile in June 2018.

4.3.2 Option 2 – Added groyne

Option 2 incorporates the current management works as detailed in the status quo option, however additionally recommends the construction of a new geotextile sand container groyne upstream of the Sand Trap (**Figure 4-2**). The primary intention of the proposed geotextile sand container groyne is to contain the Sand Trap to a designated area within the City's managed land and thus facilitate more streamlined future coastal management. Secondary intentions for the proposed groyne are to temporarily regenerate beach widths along the upstream Crystal Beach shoreline and increase the sand trapping capacity of the system. The increased sand trapping capacity will allow a temporary reduction in the operational maintenance costs associated with the Sand Trap, until such time when the proposed groyne becomes saturated.

Construction of the additional groyne is anticipated to provide an additional 15,000m^3 of sand storage capacity and delay operational extraction from the Sand Trap by approximately 2 years post construction.

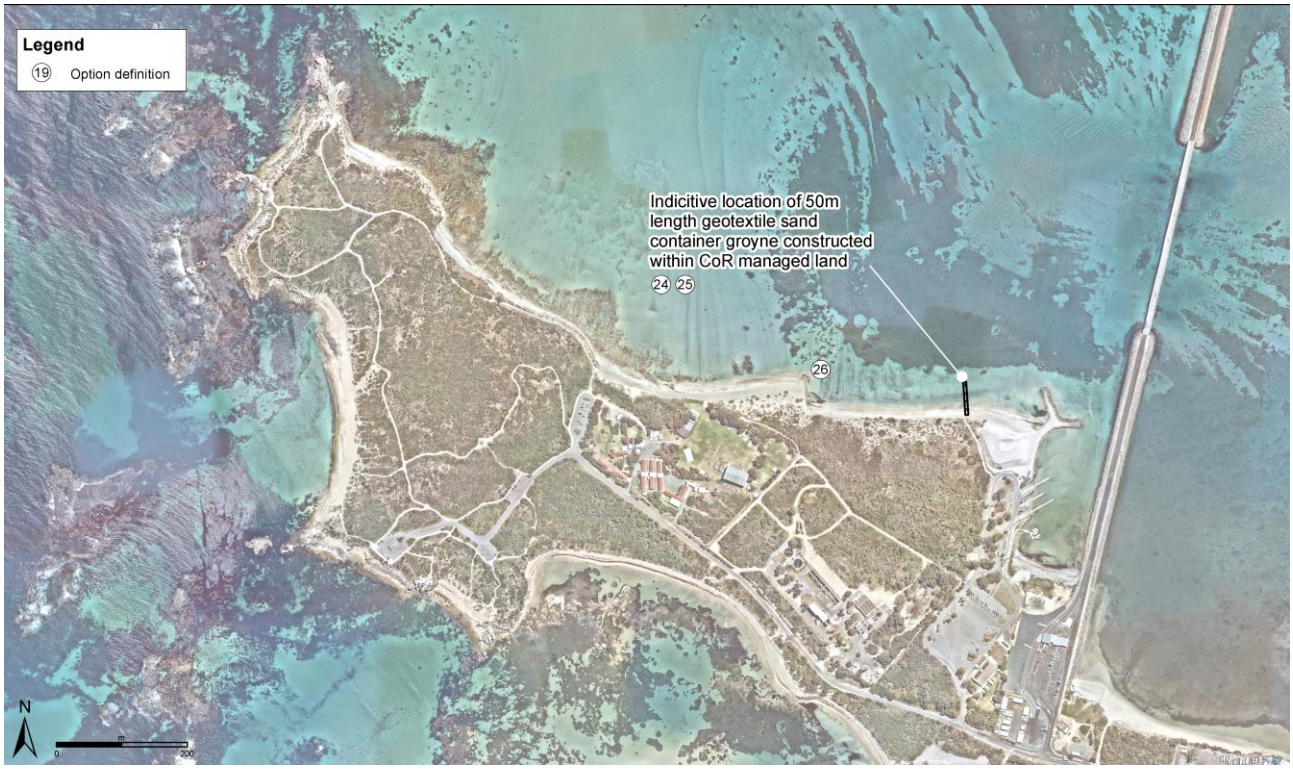

Figure 4-2 Sector 1: Option 2 – Added groyne

4.3.3 Option 3 – Shift Spur Groyne northward and added groyne

Option 3 incorporates the current management works undertaken in the Sector, the new geotextile sand container groyne detailed in Option 2 and a variation of the Spur Groyne further offshore to better allow for additional sand trapping capacity and potential future expansion of the Point Peron Boat Launching Facility (**Figure 4-3**). The City has committed $1million for upgrade of the Spur Groyne in 2020. The proposed shift in footprint of the Spur Groyne is anticipated to be incorporated in the budget for these works. The northward shift of the Spur Groyne will increase the sand trapping capacity of the system and allow a further reduction in the operational maintenance costs associated with the Sand Trap, until such time when the proposed groyne and re-configured Spur Groyne becomes saturated.

This Option is anticipated to provide an additional 30,000m3 of sand storage capacity and delay operational extraction from the Sand Trap by approximately 4 years post construction. The shift is anticipated to facilitate future expansion of the Point Peron Boat Launching Facility by allowing room for additional boat ramps to the north of the existing ramps.

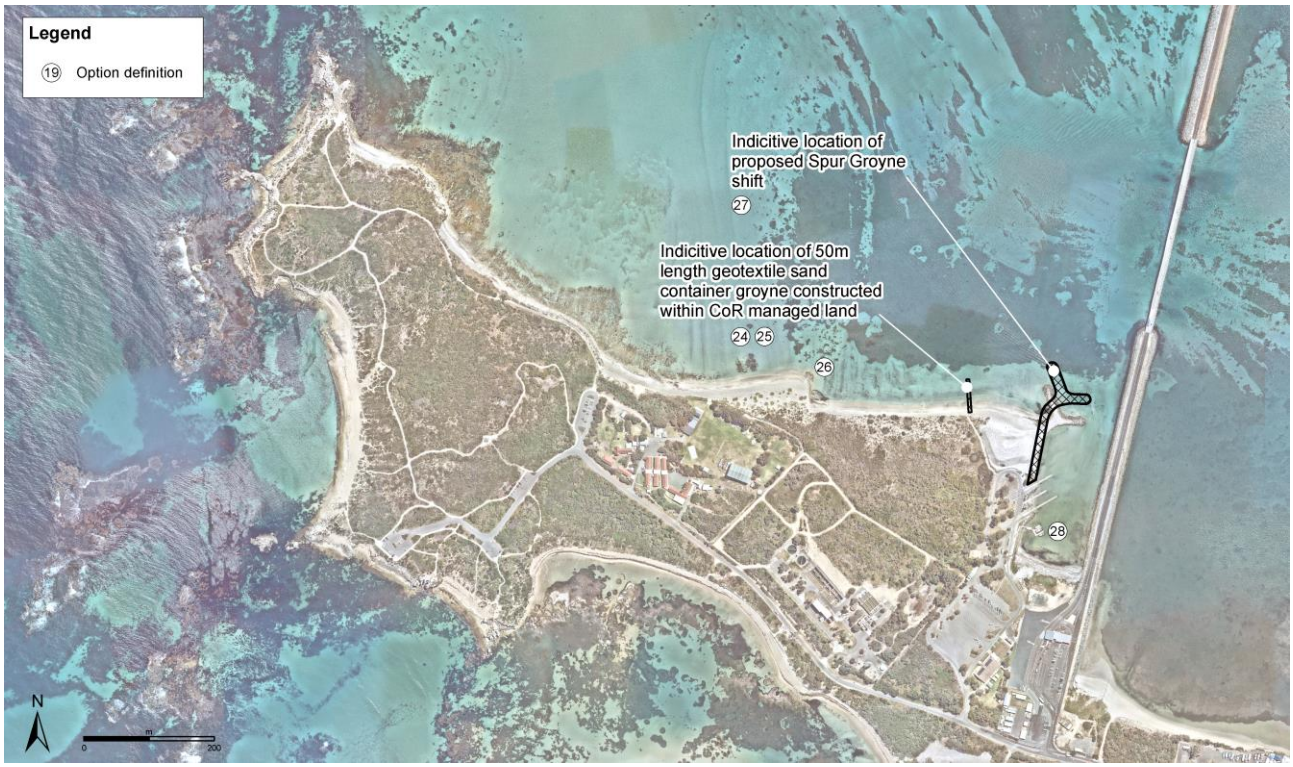

Figure 4-3 Sector 1: Option 3 – Shift Spur Groyne northward and added groyne

Table 4-2 Sector 1 - Option definition

Sector 1 – Cape Peron North		Option 1 - Status quo								Option 2 - Added groyne								Option 3 – Added groyne and shift Spur Groyne northward							
		Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose
Assets	Groyne - Spur	1					2			1					2			1					2,27		
	Groyne - GSC	3								3					26			3					26		
	Groyne - New													24								24			
	Breakwater and revetments (boating)	4					2			4					2			4					2		
	Sand Trap	5	6		7					5	6		7					5	6		7				
	Sand storage area	8	9		7			10		8	9		7			10		8	9		7			10	
	Navigation channel	11	6	12	13					11	6	12	13					11	6	12	13				
	Boat ramp	14		15						14		15						14		15,28					
	Boating facility maritime structures	16	17				18			16	17				18			16	17	28			18		
	Sand supply (Natural - Feeds and banks)	19								19								19							
	Natural amenity (beach, reserve)	20	21		13					20	21	25	13					20	21	25	13				
	Parking	22					23			22					23			22		28			23		

[1] Spur Groyne originally constructed to create a protected area for boat launching and upgraded in 1995 to prevent sedimentation of the Point Peron Boat Launching Facilities.

[2] The City has committed $1million budget for upgrade of the Spur Groyne in 2020 as recommended in 2019. The budget also covers revetment modifications.

[3] Geotextile Sand Container Groyne constructed in 2013 to manage erosion on the beaches to the west of the Spur Groyne.

[4] Point Peron Boat Launching Facility rock revetments.

[5] Sand Trap located to the west of Point Peron Boat Launching Facilities, formed as a result of construction of the Spur Groyne in 1995. The sand trap reaches saturation point at 5,000m3. It is excavated twice annually pre and post winter (5,000m3 per campaign is excavated).

[6] The Sand Trap is extracted twice per year, pre and post winter. Each campaign extracts 5,000m3 using one long reach excavator and 2 loaders (total extraction of 10,000m3 per year). During these works, up to 2,500m3 is also extracted from the lee of the Spur Groyne (sand slug). Historical campaigns have cost in the order of $6.50/m3 for excavation and stockpiling. The City has a budget of approximately $150,000 annually for the removal of sand within Sector 1 (Sand Trap and Point Peron Boat Launching Facility combined).

[7] During extraction campaigns from the Sand Trap, The City commissions the contractor to carry out pre and post work surveys of the Point Peron Sand Stockpile. Approximately $1,500 is budgeted per survey.

[8] Point Peron Sand Stockpile area for sand storage located to the south of the Spur Groyne which has a capacity of approximately 20,000m3.

[9] Wind-blown sand issues are prevalent at the Point Peron Sand Stockpile, however due to the orientation of Cape Peron, wind-blown sand is primarily blown toward the water due to the summer Seabreeze.

[10] The City reuses the sand from the Point Peron Sand Stockpile for the nourishment of beaches. Placement is generally dictated by beach demand and DBCA approvals. Generally, the sand stockpiled is used before the stockpile becomes saturated. the City has a budget of $180,000 for sand nourishment throughout the City - Nourishment sand generally comes from the Point Peron Sand Stockpile.

[11] Point Peron Boat Launching Facility navigation channel.

[12] The City is planning on carrying out a campaign to dredge the Point Peron Boat Launching Facility navigation channel in 2021. As part of these planned works, a signage strategy is currently being explored.

[13] The City currently has a budget of $3,000 - $3,500 annually to monitor the Point Peron Navigation Channel and Crystal Beach. Post construction of the GSC Groyne, it was a requirement of DBCA for the City to monitor Crystal Beach for two years. This requirement has expired; However, the City has continued to do so.

[14] Four formal concrete boat ramps at Point Peron Boat Launching Facility.

[15] The City have expressed interest in developing informal launching facilities adjacent to the current Point Peron Boat Launching Facility ramps.

[16] Point Peron Boat Launching Facilities maritime structures (holding jetty, decking, floating modules, fenders etc.)

[17] The City currently has a budget of approximately $20,000 annually for the maintenance of the Point Peron Boat Launching Facility maritime structures. This work is generally undertaken prior to summer and was last undertaken in 2019/2020.

[18] The City has committed to a budget of $1million for the upgrade of the Point Peron Boat Launching Facility maritime structures and reversing bay. The works are scheduled for 2020.

[19] Large onshore feed from Garden Island.

[20] Informal limestone seawall constructed by DBCA.

[21] The City has historically undertaken nourishment at Crystal Beach using sand from the Sand Trap and Point Peron Sand Stockpile.

[22] Approximately 24 car only and 99 car and boat trailer parking bays at Point Peron Boat Launching Facility.

[23] The City have committed to a budget of $1.5million in 2021 for landside civil works at point Peron Boat Launching Facility which includes upgrades to car park/boat trailer parking capacity to 215 bays. This work will be applied for through the RBFS. Note a maximum of $750,000 per $1,000,000 is possible through the RBFS.

[24] Construct new groyne within City of Rockingham reserve to the west of the Spur Groyne.

[25] Plan to develop a sand nourishment management program which aims to periodically target predefined sectors of coastline. The management plan should incorporate details on location, frequency, volumes, sand compatibility and timeframes.

[26] Upgrade existing GSC Groyne to: a) replace damaged/ dislodged bags, b) address downstream erosion undermining coastal protection e.g. Landward extension of the groyne or renourishment.

[27] Shift the Spur Groyne north as part of the scheduled upgrade works to allow the construction of an additional pontoon and new boat ramps to the north of the existing ramps.

[28] Subsequent to the Spur Groyne upgrade works, plan to upgrade/ build new boat ramps, maritime structures and parking facilities to cater for future demand.

4.4 Multi-criteria Assessment

Table 4-3 Sector 1 – Multi-criteria assessment

Sector 1 – Cape Peron North		Option 1 - Status quo		Option 2 - Added groyne		Option 3 - Shift Spur Groyne northward and added groyne	
Technical feasibility	Performance	3	– Minimum requirement due to ageing assets – Risk of shoreline erosion	4	– Better erosion management – Better caters for upstream shoreline erosion – Creates additional sand trapping capacity – Increased lifespan of GSC groyne	5	As Option 2 plus: – Potential boat ramp capacity increase – Additional sand trapping capacity – Reduced risk of sand bypassing into boat launching facility basin
	Safety	3	– As long as maintenance is upheld, no impact on safety	3	– As long as maintenance is upheld, no impact on safety	3	– As long as maintenance is upheld, no impact on safety
Economic viability	CapEx	3	– Baseline for Spur Groyne upgrade (assume rock protection perimeter 250m length at $7,500/m: $1,875,000) – Total of $1,875,000	2	– Baseline for Spur Groyne upgrade (assume rock protection perimeter 250m length at $7,500/m: $1,875,000) – GSC groyne (50m assume $7,500/m: $350,000) – Total of $2,250,000	2	– Baseline for Spur Groyne upgrade (assume rock protection perimeter 250m length at $7,500/m: $1,875,000) – GSC groyne (50m assume $7,500/m: $350,000) – Total of $2,250,000
	OpEx (timing varies with material)	3	– Rock work: Assume 50% CapEx per 40years: $937,000/40 years – Sand Trap maintenance: 2*7,500m3/year at $6.50/m3 + $50,000 prelim (to nearby Point Peron Sand Stockpile): $147,500/year	4	– Rock work: Assume 50% CapEx per 40years: $937,000/40 years – Assume 50% of CapEx/15year (GSC): $187,500/15 years – Sand Trap maintenance: cost as per Option 1 (but starting year 0 + 3years). Assume 2 years to fill new groyne compartment + 1 year to fill Sand Trap	5	– Rock work: Assume 50% CapEx per 40years: $937,000/40 years – Assume 50% of CapEx/15year (GSC): $187,500/15 years – Sand Trap maintenance: Cost as per Option 1 (but starting year 0 + 5years). Assume 2 years to fill new groyne compartment + 3 year to fill Sand Trap
	Net present cost at 10 years	3	– $3,170,000	2	– $3,260,000	4	– $2,990,000
Environmental and social desirability	Impact	3	– Baseline impact (Spur Groyne upgrade works)	2	Baseline impact plus: – works for new groyne	1	– Baseline impact plus new length groyne plus new footprint for shifted Spur Groyne
	Regulation	3	– Baseline approvals	3	Baseline approvals plus: – small nearshore footprint for mid groyne	2	– Baseline approvals plus: – Small nearshore footprint for new groyne – Change of infrastructure footprint within Marine Park
	Public acceptance	3	– Baseline acceptance	3	– Minor variation from baseline acceptance	4	– Expanded boating facility basin resulting in improving operability
	Independent operation from adjacent coastal managers	2	– Sand Trap excavation activities directly impact upstream shoreline erosion in DBCA managed land	3	– Improved separation with adjacent sediment cell/ DBCA managed land	3	– Improved separation with adjacent sediment cell/ DBCA managed land
TOTAL SCORE		**26**		**26**	**Least preferred**	**29**	**Preferred option**

4.5 Sensitivity

Sensitivity analysis of sub-criteria weightings has been undertaken to account for stakeholder ambiguity. The results of the analysis are presented in **Figure 4-4** below. The results suggest that the equal weighting of sub-criteria adopted in the MCA process provide a satisfactory indication of the preferred option under various distributions of weightings. In this case, Option 3 is clearly the most preferred option, but the second-best option is less clearly defined between option1 and option 2.

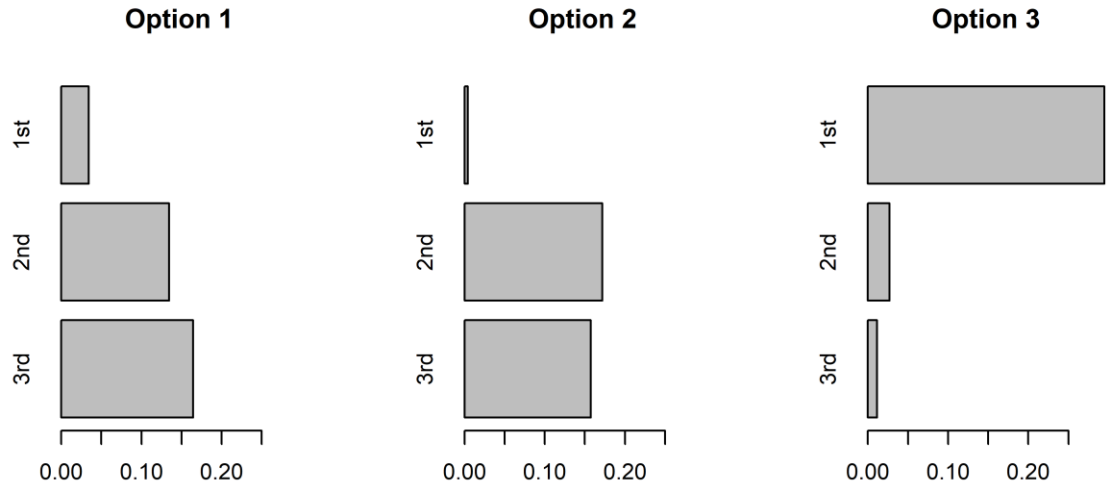

Figure 4-4 Sector 1 sensitivity analysis

4.6 Preferred Option

The preferred option for Sector 1 is *Option 3 – Shift Spur Groyne northward and added groyne.* The option involves the construction of a new geotextile sand container groyne upstream of the existing Spur Groyne and upgrade works to shift the existing Spur Groyne northward.

4.6.1 Benefits

- Increased capacity for future recreational boating facilities;
- Increased sand trapping capacity;
- Reduction in operational expenditure between 0-5 years;
- Marginal decrease in NPV10 by 5% or approximately $180,000 from baseline;
- Improved operability of Point Peron Boat Launching Facility; and
- Improved independence of management operations from key stakeholder (Department of Biodiversity, Conservation and attractions.

4.6.2 Trade-offs (risks and limitations)

- Additional capital expenditure associated with construction of groyne; and
- More stringent environmental impact permits and approvals due to northward shift of Spur Groyne footprint.

4.6.3 Long-term adaptive pathway

The long-term adaptive pathway for the sector, as defined in the CHRMAP is managed retreat. The City's ongoing investment within the Sector, which includes the committed upgrade works at the Point Peron Boat Launching Facilities across 2020 and 2021, suggest that the implementation timeframe for the long-term adaptive pathway exceeds the near- to mid-term. The proposed geotextile sand container groyne has a design

life of approximately 15 years, as opposed to 40 years for rock protection structures. The proposed shift of the Spur Groyne is anticipated to be included in the upgrade works committed to in 2020/21. Both the proposed geotextile sand container groyne and Spur Groyne shift are not intended as shoreline protection measure against the natural long-term erosion risk highlighted in the CHRMAP. Rather, the proposed works are recommended as coastal management measures with key operational functions in the near to mid-term and do not hinder the City's long-term strategy for managed retreat.

4.6.4 Implementation timeframe

The Spur Groyne is currently scheduled for upgrade in 2020/21. It is proposed that the groyne be shifted north as part of these works. Construction of the geotextile sand container groyne is likely to be dictated only by funding and environmental approval constraints, hence the preferred option is seen as viable to be implemented in the near term (1-3 year planning horizon).

5 Sector 2 – Cape Peron South

5.1 Sector Profile

Table 5-1 Profile – Sector 2: Cape Peron South

Profile	Definition
Location	Sector 2 is bound by the northernmost extent of Cape Peron and the shoreline sediment bump in the lee of Bird Island. The shoreline of Sector 2 corresponds to Secondary Cell 14C for the Vlamingh Coast (Stul et al, 2015). The Sector is situated on Cape Peron, a predominantly rocky headland with sandy beaches fronting north, south and west.
Land use	Natural parks and recreation reserve, public purpose lots comprising Point Peron Camp School and Point Peron Wastewater Treatment Plant.
Adaptive pathway (beyond 2030)	Long term managed retreat as per CHRMAP
Coastal processes	
Exposure	Low -medium energy wave climate, sheltered from northerly events by Cape Peron and offered protection from the south-west by the Shoalwater Islands and offshore Murray and Five Fathom Reefs. During storm events, waves reach the shoreline by penetrating the gaps in the offshore reefs and islands.
Sediment dynamics	The Sector is characterised by two embayment's defined by sediment bumps which have formed in the lee of White Rock and Bird Island. The southern embayment has been subject to a gradual trend of erosion.
Vulnerability to erosion	2030 erosion hazard line suggests shoreline recession of up to 80m within Sector. Infrastructure including the Point Peron Foreshore Carpark (SW) and road infrastructure within extent of 2030 erosion hazard line. Water Authority Treated Waste Water Pipe that enters the water in this Sector is highly likely to be exposed. Refer CHRMAP for definition.
Vulnerability to inundation	Low lying land in the vicinity of the Point Peron Wastewater Treatment Plant susceptible to coastal inundation. Refer CHRMAP for definition.
Land tenure	
Shoreward	The Sector is contained within the Cape Peron Reserve (Reserve 48968), which is owned by the Western Australian Planning Commission and managed by the Department of Biodiversity, Conservation and Attractions. The Point Peron Wastewater Treatment Plant, managed by the Water Corporation is also located within the vicinity of this Sector.
Seaward	The offshore water body is primarily characterised by the Shoalwater Bay Special Purpose Zone which extends from the high-water mark to approximately the western tip of Cape Peron. Further offshore as well as the section of shoreline south of John Point is characterised by the Shoalwater Islands Marine Park General Purpose Zone.
Social and recreational value	Sector 2 contains the majority of the Cape Peron Reserve and is very popular for nature experience, shore based and offshore snorkeling and diving, dog walking, picnics, walking and hiking.
Environmental value	Fringing the Shoalwater Bay Wildlife Conservation Special Purpose Zone, the Sector holds significant environmental value including areas of seagrass, sand, subtidal macroalgae dominated reef and rocky shore communities. This Sector also encompasses breeding and feeding grounds for migratory and resident seabirds and is a feeding area for the Australian sea lion. Bottlenose dolphins are also common within the Sector.

city of Rockingham
where the coast comes to life

N

1:6,000 Scale at A3

m
0 200

Sector 2 - Cape Peron South

FIGURE 5-1

Cardno

Map Produced by Cardno (WA) Pty Ltd
Date: 2019-11-25
Coordinate System: GDA 1994 MGA Zone 50
Project: CW108200
Map: Figure 5-1_Sector 2 02.mxd 01
Imagery: Nearmaps.com (October 2019)

5.2 Key Management Issues

> S2-01 Loss of beach widths throughout Sector

> S2-02 Loss of Point Peron Foreshore Carpark (SW) infrastructure

5.3 Option Definition

5.3.1 Option 1 – Status quo - Ad hoc nourishment

Historically, the City's coastal management within Sector 2 has generally been limited to ad-hoc nourishment works along the eroding section of beach fronting the Water Corporation Waste Water Treatment Plant. The DBCA have expressed interest in the continued efforts to maintain beach widths within the Sector. Although the section of beach within this sector is not necessarily in the highest demand for nourishment in the study area, it's close proximity to the Point Peron Stockpile, offers opportunity to better streamline the management of Sector 1, particularly with respect to continually finding placement location for excess stockpiled material.

5.3.2 Option 2 – Nourishment - Truck and place

Option 2 intends to develop and implement a formalised nourishment operation for the eroding section of beach within Sector 2, using material extracted from the Sand Trap within Sector 1 (**Figure 5-2**). This option proposed the nourishment works be undertaken via extraction and truck hauling. Due to the majority of land within Sector 1 and 2 being contained within the Cape Peron Reserve, the use of trucks to transport sand to and from the Sand Trap would avoid City owned infrastructure. The primary intention of establishing the formalised nourishment operation is to mitigate intermediate stockpiling, thus reduce operational expenditure and potentially freeing up land for other uses such as car parking infrastructure. Secondary intentions include the maintenance of beach widths within Sector 2.

Figure 5-2 Sector 2: Option 2 – Nourishment - Truck and place

5.3.3 Option 3 – Nourishment - Slurry pump and temporary pipe

Option 3 is built on the intentions of Option 1. The Option develops a formalised nourishment operation for the beaches within the Sector by incorporating a temporary pipeline between the Point Peron Sand Trap and section of eroding beach (**Figure 5-3**). Upstream at the Sand Trap, a mobile screening and pumping unit, commonly referred to as a 'Slurrytrack' would be mobilised on site for the duration of the nourishment campaign. Subsequent to screening the sand for debris, the Slurrytrack would mix the sand with water to form

a slurry and pump the material toward the discharge on the south of Cape Peron. Upon completion of the campaign, the pipeline and Slurrytrack would be demobilised from site.

Figure 5-3 Sector 2: Option 3 – Nourishment - Slurry pump and temporary pipe

5.3.4 Option 4 – Nourishment - Slurry pump and permanent pipe

Option 4 also incorporates a formalised nourishment operation between the Point Peron Sand Trap and section of eroding beach within Sector 2, however involves the construction of approximately 500m length of a permanent buried pipeline (**Figure 5-4**). The same 'Slurrytrack' screening and pumping unit as defined in Option 3 will need to be mobilised on site for the duration of the nourishment campaign.

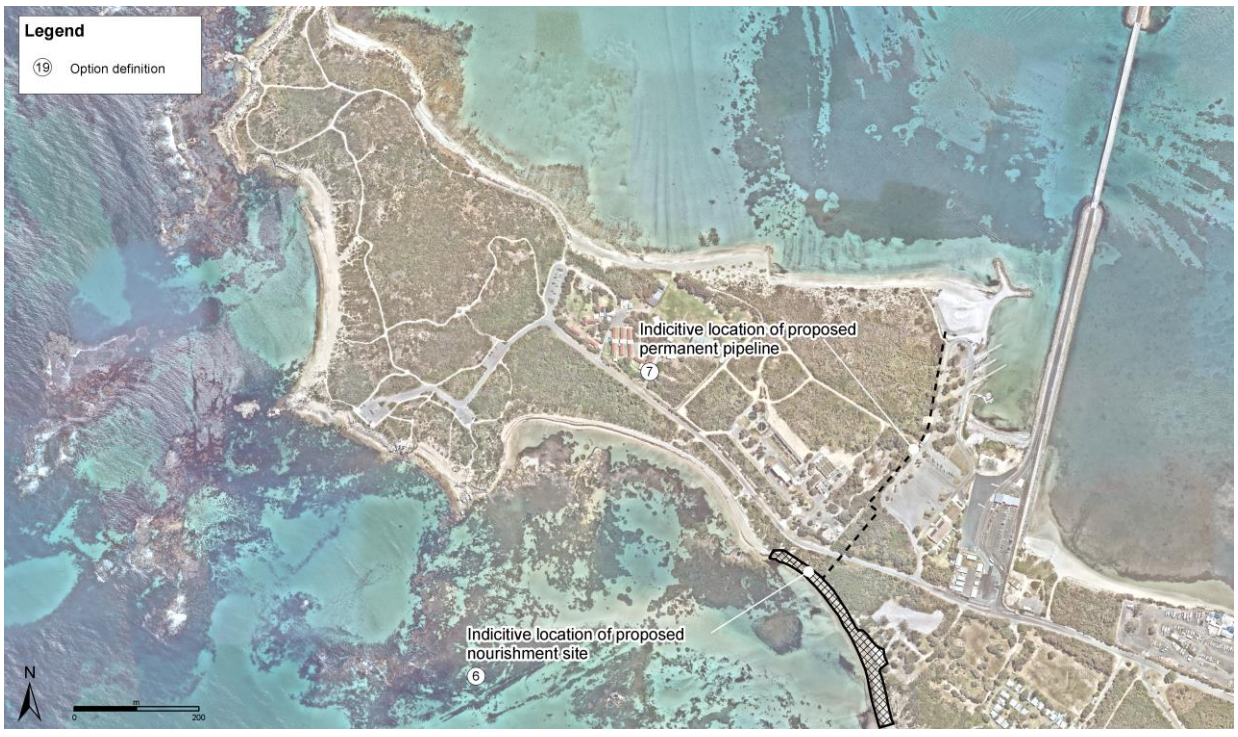

Figure 5-4 Sector 2: Option 4 – Nourishment - Slurry pump and permanent pipe

Table 5-2 Sector 2 – Option definition

Sector 2 – Cape Peron South		Option 1 - Status quo								Option 2 - Sand bypassing via off-road dump trucks								Option 3 - Nourishment - Slurry pump + temporary pipe								Option 4 - Nourishment - Slurry pump + permanent pipe							
		Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose
Assets	Sand supply (Natural - Feeds and banks)	3								3								3								3							
	Natural amenity (beach, reserve)	1	2							1	4							1	5							1	6						
	Pipeline																										6						

[1] Beach within Sector

[2] The City has historically undertaken beach nourishment along the beach fronting the Wastewater Treatment Plant using sand extracted from the Sand Trap within Sector 1. Nourishing this section of beach is beneficial to the City due to reducing haulage from the Point Peron Sand Stockpile and avoiding City owned infrastructure (roads etc.). Between 2014 and 2016, three nourishment campaigns were undertaken. The volumes of which were 11,000m3, 5,000m3 and 5,000m3.

[3] Offshore sand feed from White Rock and Bird Island.

[4] Develop a formalised nourishment program in collaboration with DBCA and consistent with the sand management requirements in Sector 1. The purpose of the nourishment program is to: a) managing the stockpiled sand within Sector 1 and b) manage the eroding section of beach within Sector 2. Nourishment works to be undertaken via truck hauling from the Sand Trap.

[5] Develop a formalised nourishment program in collaboration with DBCA and consistent with the sand management requirements in Sector 1. The purpose of the nourishment program is to: a) managing the stockpiled sand within Sector 1 and b) manage the eroding section of beach within Sector 2. Nourishment works to be undertaken using 'Slurrytrack' and temporary pipeline between the Sand Trap and the section of beach. Pipeline to be installed and removed during each nourishment campaign.

[6] Develop a formalised nourishment program in collaboration with DBCA and consistent with the sand management requirements in Sector 1. The purpose of the nourishment program is to: a) managing the stockpiled sand within Sector 1 and b) manage the eroding section of beach within Sector 2. Nourishment works to be undertaken using 'Slurrytrack' and permanent pipeline installed between the Sand Trap and the section of beach.

[7] Construct approximately 500m length of buried pipeline between the Sand Trap and proposed nourishment site

5.4 Multi-criteria Assessment

Table 5-3 Sector 2 – Multi-criteria assessment

Sector 2 – Cape Peron South		Option 1 - Status quo - Ad hoc nourishment		Option 2 - Nourishment - Truck and place		Option 3 - Nourishment - Slurry pump + temporary pipe		Option 4 - Nourishment - Slurry pump + permanent pipe	
Technical feasibility	Performance	0	– DBCA shoreline erosion not addressed systematically – Point Peron Sand Stockpile capacity being exceeded and rapidly managed by ad hoc beach nourishment throughout City	4	– Improved beach widths – Systematic and efficient extraction from Point Peron Sand Stockpile to cater for capacity constraints	4	– Improved beach widths – Systematic and efficient extraction from Sand Trap directly to cater for capacity constraints	4	– Improved beach widths – Systematic and efficient extraction from Sand Trap directly to cater for capacity constraints
	Safety	2	– Baseline safety – Minor infrastructure at risk of damage from the erosion	4	– Provide erosion buffer for infrastructure	5	– Provide erosion buffer for infrastructure – Reduce road safety implications associated with truck haulage	5	– Provide erosion buffer for infrastructure – Reduce road safety implications associated with truck haulage.
Economic viability	CapEx	3	– Not applicable - operation only	3	– Not applicable - operation only	3	– Not applicable - operation only	2	– Permanent pipeline: $245,000
	OpEx	5	– Excavation from Sand Trap to Point Peron Sand Stockpile ($147,500 cost included in Sector 1) – Reload from Point Peron Sand Stockpile, transport and beach placement: $196,000 – NET OpEx: $196,000 per year from year 0 (assuming status quo in Sector1)	1	– Excavation from Sand Trap to Point Peron Sand Stockpile ($147,500 cost included in Sector 1) – Reload from Point Peron Sand Stockpile, transport and beach placement: $196,000 – NET OpEx: $196,000 per year from year 5 (assuming preferred option for Sector 1)	2	– Excavation from Sand Trap to Point Peron Sand Stockpile ($147,500 cost included in Sector 1) no longer required = -$147,500 (saving) – Load from beach directly, transport (slurry) and placement cost: $237,920 – NET OpEx: $90,500 per year from year 5 (assuming preferred option for Sector 1)	3	– Excavation from Sand Trap to Point Peron Sand Stockpile ($147,500 cost included in Sector 1) no longer required = -$147,500 (saving) – Load from beach directly, transport (slurry) and placement cost: $215,000 – NET OpEx: $67,500 from year 5 (assuming preferred option for Sector 1)
	Net present cost at 10 years	2	– $1,720,000	3	– $980,000	5	– $450,000	4	– $580,000
Environmental and social desirability	Impact	4	– Low impact – Current management assists DBCA	4	– Low impact – current management assists DBCA	2	– Yearly clearing of vegetation may be required to lay down temporary pipeline.	3	– One-off clearing of vegetation for trenching – Installation of permanent pipeline followed by revegetation.
	Regulation	4	– Approvals likely required for nourishment	4	– Approvals likely required for nourishment	3	– Slightly more onerous approvals likely required for nourishment – Clearance along pipeline route	3	– Slightly more onerous approvals likely required for nourishment – Clearance along pipeline route
	Public acceptance	3	– Baseline acceptance – Likely to have some opposition if erosion continues.	2	– Improved beach widths – Trucking activities	1	– Annual likely opposition of construction works within Cape Peron – Visual appearance of pipeline entrance and exit	3	– One-off likely opposition of construction works within Cape Peron – Visual appearance of pipeline entrance and exit
	Independent operation from adjacent coastal managers	4	– DBCA managed land	3	– Requires ongoing agreement between DBCA and CoR	3	– Requires ongoing agreement between DBCA and CoR	3	– Requires ongoing agreement between DBCA and CoR
TOTAL SCORE		**27**	**Least preferred**	**28**		**28**		**30**	**Preferred option**

5.5 Sensitivity

Sensitivity analysis of sub-criteria weightings has been undertaken to account for stakeholder ambiguity. The results of the analysis are presented in **Figure 5-5** below. The results suggest that the equal weighting of sub-criteria adopted in the MCA process provide a satisfactory indication of the preferred option under various distributions of weightings. In this case, Option 4 is clearly the most preferred option.

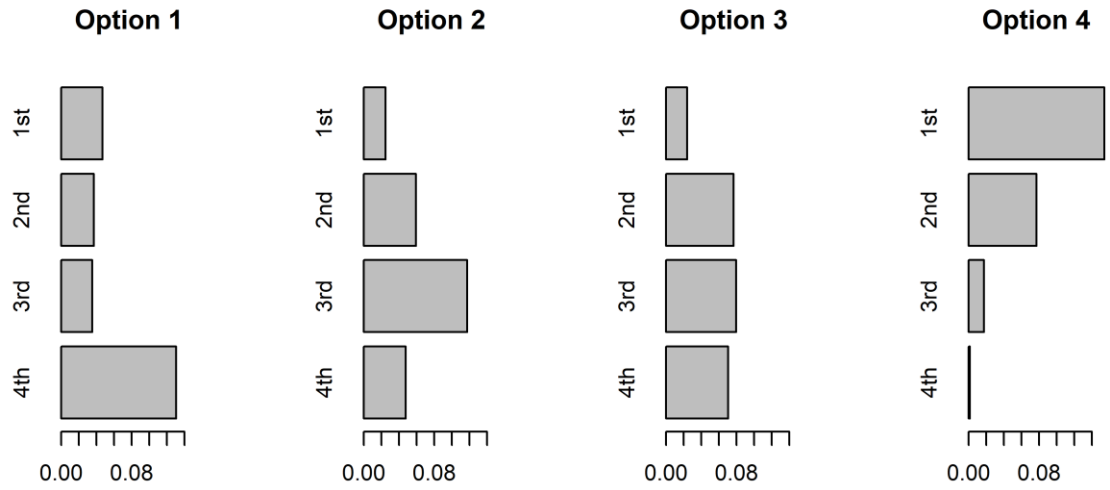

Figure 5-5 Sector 2 sensitivity analysis

5.6 Preferred Option

The preferred option for Sector 2 is *Option 4 – Nourishment - Slurry pump and permanent pipe.* This option involves the construction of approximately 500m length of permanent buried slurry pumping pipeline between the Point Peron Sand Trap and section of beach along the south of Cape Peron.

The capital expenditure for the preferred option equates to less than 2 years' worth of current management operations associated with extraction from the Sand Trap and ad-hoc nourishment throughout Rockingham. Therefore, Option 3 will remain economically favourable so long as at least two slurry pumping campaigns are carried out across the 10-year planning horizon. It is noted that Option 3 does not prevent the stockpiling and "double handling" of material when necessary for the nourishment of other sections of coastline. The cost savings and benefits associated with option 3 are greatest when the Sand Trap is approaching saturation.

5.6.1 Benefits

Potential win-win solution. Improved local beach widths. No trucks on the road

- Potential win-win solution between City of Rockingham and Department of Biodiversity, Conservation and attractions;
- Improved local beach widths;
- Systematic and efficient extraction directly from the Sand Trap with no intermediate stockpiling, potentially freeing land for other use such as parking;
- One-off operation during Sand Trap clearing;
- One-off clearing of vegetation for installation of permanent pipeline followed be re-vegetation;
- Reduction in operational expenditure due to streamlining of sand management without the need to double handle stockpiled material; and

- Substantial NPV10 reduction of 66% or approximately $1,140,000 from status quo primarily due to transport costs.

5.6.2 Trade-offs (risks and limitations)

- Minor capital expenditure associated with construction of permanent buried pipeline;
- Potentially more onerous approval requirements due to one-off vegetation clearance; and
- Requires coordination with key stakeholders and ongoing agreement between the City of Rockingham and the Department of Biodiversity, Conservation and attractions;

5.6.3 Long-term adaptive pathway

The long-term adaptive pathway for the sector, as defined in the CHRMAP is managed retreat. While nourishment is generally associated with protective management, the preferred option is not intended as shoreline protection measure against the natural long-term erosion risk highlighted in the CHRMAP. Rather, the proposed works are recommended as coastal management measures with key operational functions in the near to mid-term which align with Department of Biodiversity, Conservations and Attractions management objectives while not hindering the City's long-term strategy for managed retreat.

5.6.4 Implementation timeframe

Implementation of the preferred option is likely to be dictated only by funding and environmental approval constraints, hence the preferred option is seen as viable to be implemented in the near term (1-3 year planning horizon).

6 Sector 3 – Shoalwater Bay North

6.1 Sector Profile

Table 6-1 Profile – Sector 3: Shoalwater Bay North

Profile	Definition
Location	Sector 3 is situated within an embayment at the north of Shoalwater Bay. The north and south of the embayment are characterised by accreted land in lee of Bird Island and Seal Island respectively. The shoreline of Sector 3 corresponds to Secondary Cell 14B for the Vlamingh Coast (Stul et al, 2015).
Land use	Foreshore parks with a combination of natural and built elements, residential and public purpose reserves comprising L&S Recreation Centre, Maritime Union of Australia Holiday Camp and Rockingham Recreation Centre.
Adaptive pathway (beyond 2030)	Long term managed retreat as per CHRMAP
Coastal processes	
Exposure	Low – medium energy wave climate offered protection from the south-west by the Shoalwater Islands and offshore Murray and Five Fathom Reefs. During storm events, waves reach the shoreline by penetrating the gaps in the offshore reefs and islands.
Sediment dynamics	Waves diffracting around Bird and Seal Island have resulted in pockets of low wave energy and subsequent accretion of the shoreline in the Islands lee. Shoreline relatively stable. Dynamic nearshore sand feeds evident by pockets of low seagrass accrual.
Vulnerability to erosion	2030 erosion hazard line suggests shoreline recession of up to 25m within Sector. There is no Infrastructure within extent of 2030 erosion hazard line. Refer CHRMAP for definition.
Vulnerability to inundation	The Sector has a low risk of coastal inundation. Refer CHRMAP for definition.
Land tenure	
Shoreward	The northern portion of the Sector is contained within the Cape Peron Reserve (Reserve 48968) which is owned by the Western Australian Planning Commission and managed by the Department of Biodiversity, Conservation and Attractions. The foreshore south of Boundary Road is managed by the City of Rockingham.
Seaward	The offshore water body is primarily characterised by the Shoalwater Bay Special Purpose Zone which extends from the high-water mark to approximately the western tip of Cape Peron. Within the nearshore waters of the Sector lies the 79-hectare Seal Island Sanctuary Zone.
Social and recreational value	Sector 3 contains portions of the Cape Peron Reserve, which is a popular area for nature experience. The Sector is also valued for offshore diving and fishing, dog walking, picnics, walking, hiking, kayaking/ canoeing and stand up paddle boarding and kite surfing. The offshore Seal Island Sanctuary Zone provides important commercial tourism.
Environmental value	Fringing the Shoalwater Bay Wildlife Conservation Special Purpose Zone, the Sector holds significant environmental value including areas of seagrass, sand, subtidal macroalgae dominated reef and rocky shore communities. The Seal Island Sanctuary Zone encompasses long term seagrass monitoring sites and provides a buffer area to Seal Island, which is the most important Australian sea lion haul-out area within the Marine Park. In addition, Seal Island in conjunction with Shag Rock, are important for seabird nesting.

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Sector 3 - Shoalwater Bay North

FIGURE 6-1

Cardno

Date: 2019-11-25
Coordinate System: GDA 1994 MGA Zone 50
Project: CW1082000
Map: Figure 6-1_Sector 3 02.mxd 01
Imagery: Nearmaps.com (October 2019)

6.2 Key Management Issues

No key issues within the studies planning horizon have been identified for Sector 3.

6.3 Option Definition

6.3.1 Option 1 – Status quo

The City do not currently undertake coastal management within Sector 3. Due to the relative stability of the shoreline within this Sector, no management options have been defined within the planning horizon of this Study.

7 Sector 4 – Shoalwater Bay South

7.1 Sector Profile

Table 7-1 Profile – Sector 4: Shoalwater Bay South

Profile	Definition
Location	Sector 4 is situated within the embayment bound between Seal Island and Penguin Island at the south of Shoalwater Bay. The shoreline of Sector 4 corresponds to Secondary Cell 14B for the Vlamingh Coast (Stul et al, 2015).
Land use	Foreshore parks with a combination of natural and built elements, residential and commercial.
CHRMAP long term adaptive pathway (beyond 2030)	Long-term managed retreat
Coastal processes	
Exposure	Low -medium energy wave climate, offered protection from the south-west by the Penguin Island and the offshore sand feed. During storm events, waves reach the shoreline by penetrating the gaps in the offshore reefs and islands. Protection from northerly events is offered by the sand feed and associated shallow waters from Seal Island.
Sediment dynamics	Swell waves generated offshore and diffracting around the outer reefs and islands have resulted in the formation of the tombolo separating Penguin Island from the mainland at Mersey Point. The head of Mersey Point has shown significant changes on seasonal, interannual and interdecadal timescales. Generally, the head of Mersey Point has been observed to fluctuate between states of northerly headings during summer and southerly headings during winter. Accretion to the north and erosion to the south of Mersey Point has been a result of continual supply of sand from Penguin Island and the sea breeze cycle which generally generates more littoral drift in the study area than the shorter duration winter storms. A seawall was constructed to the south of Mersey Point in 2003 to mitigate the risks associated with ongoing erosion. Mersey Point Jetty was reconstructed in 2018 skew to the alignment of the existing jetty as a result of the ongoing accretion of Mersey Point. Over the past 10 years, the northern portion of the embayment has shown gradual trends of erosion into the foreshore reserve. The southern portion has remained relatively stable.
Vulnerability to erosion	2030 erosion hazard line suggests shoreline recession of up to 60m within Sector. Infrastructure and amenities including Shoalwater Park, Lions Park and car park, Mersey Point Carpark and Rockingham Wild Encounters are situated within extent of 2030 erosion hazard line. Note, the Mersey Point Seawall is anticipated to provide protection to Mersey Point infrastructure. Refer CHRMAP for definition.
Vulnerability to inundation	The Sector has a low risk of coastal inundation. Refer CHRMAP for definition.
Land tenure	
Shoreward	The Sector is managed by the City of Rockingham.
Seaward	The offshore water body is primarily characterised by the Shoalwater Bay Special Purpose Zone which extends from the low-water mark to approximately the western tip of Penguin Island. Within the nearshore waters of the Sector lies the 79-hectare Seal Island Sanctuary Zone. The Penguin Island Conservation Park is situated at Penguin Island offshore from Mersey Point.
Social and recreational value	Sector 4 holds significant commercial and tourism value including access to and from Penguin Island and ecotourism within Shoalwater Bay. Lions Park is an active zone for recreational use and dog walking is popular at Shoalwater Dog Beach. Kayaking/ canoeing, stand up paddle boarding, kite surfing, recreational fishing at First and Second Rocks and on Mersey Point Jetty as well as offshore snorkeling and diving is also popular within the Sector.
Environmental value	Penguin Island is home to the largest known breeding colony of Little Penguins in Western Australia. In addition to Little Penguins, the Sector again holds significant environmental value including areas of seagrass, sand, subtidal macroalgae dominated reef and rocky shore communities.

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Sector 4 - Shoalwater Bay South

FIGURE 7-1

Cardno

Date: 2019-11-25
Coordinate System: GDA 1994 MGA Zone 50
Project: CW1082000
Map: Figure 7-1_Sector 4 02.mxd 01
Imagery: Nearmaps.com (October 2019)

7.2 Key Management Issues

> S4-01: Loss of beach widths along Sector

> S4-02: Loss of Shoalwater Park, Lions Park and car park amenities and infrastructure

> S4-03: Navigational safety implications associated with siltation at Mersey Point Jetty

> S4-04: OpEx implications associated with siltation at Mersey Point Jetty

> S4-05: Safety implications associated with aging Mersey Point Seawall

> S4-06: Functionality implications associated with aging Mersey Point Seawall

> S4-07: CapEx implications associated with aging Mersey Point Seawall

> S4-08: OpEx implications associated with aging Mersey Point Seawall

> S4-09: Vessel and fauna collision due to high use boating zone coinciding with little penguin foraging route

7.3 Option Definition

7.3.1 Option 1 – Status quo

Sector 4 has historically been the subject of significant coastal management including the construction of a seawall in 2003, beach profile monitoring and maintenance dredging from Mersey Point Jetty. Since the demolition and reconstruction of the Mersey Point Jetty approximately 150m north of the existing, maintenance works associated with navigational safety at the Jetty has slowed. The City have committed to works in 2020 to extend and reinforce the existing seawall at Mersey Point to better cater for erosion hazards. The status quo option for Sector 4 incorporates the proposed seawall works. The construction of seawalls as a shoreline protective measure generally divert erosion issues elsewhere, such as the beaches either side of, and directly in front. The City have expressed interest in maintaining the beach fronting the proposed seawall for amenity reasons.

7.3.2 Option 2 – Renourish beach in front of seawall

Option 2 involves the continual nourishment of the beach fronting the proposed seawall (**Figure 7-2**). Fed from the Penguin Island offshore sand feed, sediment south of Mersey Point is generally transported in a net eastward direction. It is predicted that the accretion of land east of the seawall, fronting the Carlisle Street Boat Ramp and Safety Bay Yacht Club is due primarily to a combination of the net easterly drift of sediments along the south of Mersey Point and the westerly drift of sediment distributed on the Tern Bank Sandbar. As such, it is likely that any nourishment works fronting the proposed seawall will be transported in an easterly direction and contribute to the ongoing sand maintenance costs at Carlisle Street, contained within Sector 5.

Figure 7-2 Sector 4: Option 2 – Nourish beach

7.3.3 Option 3 – Renourish and contain beach in front of seawall

Option 3 involves nourishment and the construction of approximately 50m length of groyne at the extent of the proposed seawall to create an artificial beach compartment (**Figure 7-3**). The primary intent of the proposed groyne is to restrict longshore sediment movement and stabilise the beach compartment fronting the proposed seawall for amenity purposes. Similar to seawalls, groynes generally divert erosion issues elsewhere, such as to the downstream side of the groyne. It is recommended that this option be accompanied by monitoring, particularly at the shoreline to the east of the proposed groyne.

Figure 7-3 Sector 4: Option 3 – Nourish and contain beach

Table 7-2 Sector 4 – Option definition

Sector 4 – Shoalwater Bay South		Option 1 - Status quo								Option 2 - Renourish beach in front of seawall								Option 3 - Renourish and contain beach in front of seawall							
		Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose
Assets	Seawall - Temporary	1					3			1					3			1					3		
	Seawall - Mersey Point	2				3				2				3				2				3			
	Seawall - New			4								4								4					
	Groyne																					14			
	Jetty	5	6		7					5	6		7					5	6		7				
	Navigation channel		8								8								8						
	Sand supply (Natural - Feeds and banks)	9	10							9	10							9	10						
	Natural amenity (beach, reserve)			12	11						13		11						12		11, 15				

[1] Temporary seawall constructed in June 2019 to the west of Mersey Point Seawall.

[2] Approximately 200m length of seawall at Mersey Point constructed parallel to Arcadia Drive in 2003.

[3] The existing temporary seawall is scheduled for upgraded in March/ April 2020. As part of the upgrade works, the Mersey Point seawall is also being extended. The extension works include construction of approximately 100m of new granite seawall to the west of the existing Mersey Point Seawall. The City has a budget of $1million for the combined works.

[4] In alignment with the long-term adaptive planning defined in the CHRMAP, the City is looking to begin scoping and planning for the design of a seawall in this Sector within next 6 -10 years.

[5] Mersey Point Jetty, demolished and reconstructed along a new alignment in August 2018. The Jetty accommodates mooring within Shoalwater Bay and is used as a departure location to access Penguin Island.

[6] The City undertakes general maintenance works on Mersey Point jetty as required.

[7] The City currently monitors sea wrack accumulation at Mersey Point Jetty. A maintenance campaign has not been undertaken to date.

[8] Prior to the demolition of the original timber Mersey Point Jetty in August 2018, maintenance of seabed levels (dredging) adjacent to Mersey Point Jetty and Penguin Island was undertaken by Rockingham Wild Encounters to improve berthing depth for Ferries and to improve safe jetty access to Rockingham Wild Encounters staff, jetty patrons and DBCA staff (Marine Park Rangers) who frequently access Penguin Island via DBCA vessels or ferry. This Sand extraction at Penguin Island and Mersey Point was supported by DBCA. Subsequent to the construction of the new jetty 150m north of the original jetty footprint (away from the sediment dynamic area), no future sand/seabed excavation is required.

[9] Large offshore sand feed from Penguin Island.

[10] A small sand nourishment source exists at Mersey Point.

[11] The City currently undertakes monitoring in the form of beach profile surveys between Mersey Road and Seaforth Road. Monitoring is undertaken twice per year with a budget of approximately, $8,500-9,000 per year for the site.

[12] Subsequent to the Mersey Point Seawall upgrade works, The City has plans to renourish the beach fronting the Mersey point Seawall to maintain beach amenity.

[13] Subsequent to the upgrade works on the Mersey Point Seawall. Develop a formalised nourishment program to maintain the beach amenity fronting the Mersey Point Seawall as per the City's intentions.

[14] Subsequent to the upgrade works on the Mersey Point Seawall, construct a groyne at the eastern extent of the seawall to create an artificial sand compartment, maintaining beach amenity fronting the Mersey Point Seawall.

[15] In addition to the existing beach monitoring between Mersey Point and Seaforth Drive, develop a monitoring plan to assess the impact on the shoreline downstream of the new groyne.

7.4 Multi-criteria Assessment

Table 7-3 Sector 4 – Multi-criteria assessment

Sector 4 – Shoalwater Bay South		Option 1 - Status quo		Option 2 - Renourish beach in front of seawall		Option 3 - Renourish and contain beach in front of seawall	
Technical feasibility	Performance	3	– Baseline erosion protection by seawall – Loss of beach amenity over time	5	– Baseline erosion protection by seawall – Temporary improved beach amenity	4	– Baseline erosion protection by seawall – Longer term improved beach amenity – Terminal groyne downstream erosion risk
	Safety	3	– Baseline	3	– Baseline	3	– Baseline
Economic viability	CapEx	3	– No CapEx	3	– No CapEx	2	– 2 x GSC groyne (2 x 50m assume $7,500/m: $750,000)
	OpEx	3	– No OpEx	1	– Regular nourishment, assume: Reload from Point Peron Sand Stockpile, transport and beach placement: $196,000 per year	2	– Less frequent nourishment, assume: Reload from Point Peron Sand Stockpile, transport and beach placement: $98,000 per year – Assume 50% of CapEx/15year (GSC): $375,000/15 years
	NPV10	3	– $0	2	– $1,960,000	2	– $1,730,000
Environmental and social desirability	Impact	3	– Potential loss of intertidal beach environment	3	– Direct impact to the environment due to the regular import of new material	3	– More stable intertidal/ beach environment. Direct impact of groynes
	Regulation	3	– Baseline approval	2	– Potential sand nourishment/ environmental management plan. .	2	– Potential sand nourishment and infrastructure development environmental management plan – Terminal groyne downstream erosion risk
	Public acceptance	3	– Loss of beach amenity	4	– Temporary improved beach amenity	3	– Longer term improved beach amenity – Potential seagrass accumulation upstream – More intrusive visual impact of groynes
	Independent operation from adjacent coastal managers	3	– Not applicable	3	– Not applicable	3	– Not applicable
TOTAL SCORE		**27**		**26**		**24**	

7.5 Sensitivity

Sensitivity analysis of sub-criteria weightings has been undertaken to account for stakeholder ambiguity. The results of the analysis are presented in **Figure 7-4** below. The results suggest that the equal weighting of sub-criteria adopted in the MCA process provide a satisfactory indication of the preferred option under various distributions of weightings. In this case, Option 1 is clearly the most preferred option.

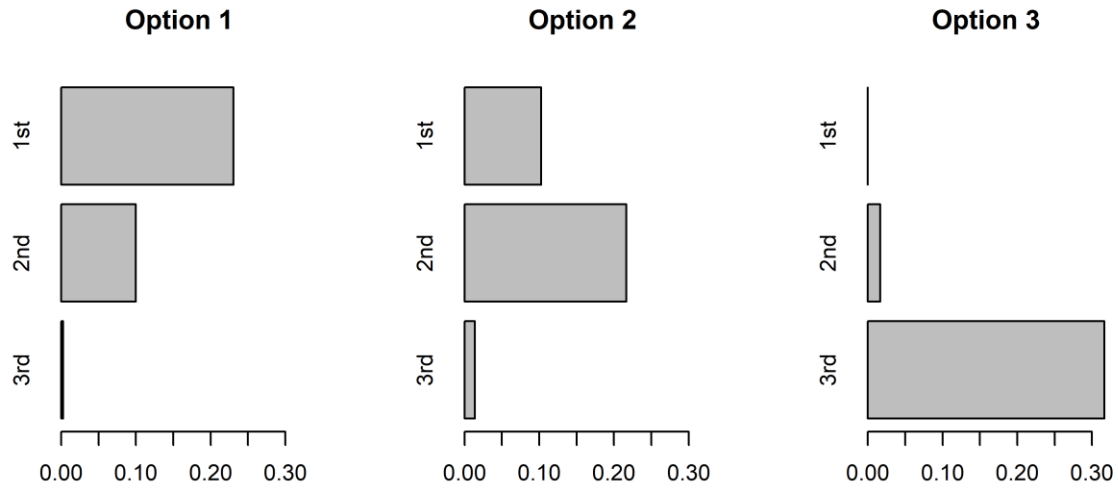

Figure 7-4 Sector 4 sensitivity analysis

7.6 Preferred Option

The preferred option for Sector 4 is *Option 1 – Status quo.* The option involves the continual management operations of the Sector in its current form. Specifically, the construction of the proposed seawall, accompanied by no sand nourishment works.

7.6.1 Benefits

> Low cost solution; and

> Minimal environmental impact and regulatory burden.

7.6.2 Trade-offs (risks and limitations)

> Progressive loss of beach and associated amenity fronting seawall, subject to natural upstream sand supply.

7.6.3 Long-term adaptive pathway

The long-term adaptive pathway for the sector, as defined in the CHRMAP is managed retreat to the north of Mersey Point and protect to the south. The status quo aligns with the long-term strategic approach adopted by the City.

7.6.4 Implementation timeframe

There is no implementation timeframe associated with the Status quo.

8 Sector 5 – Safety Bay

8.1 Sector Profile

Table 8-1 Profile – Sector 5: Safety Bay

Profile	Definition
Location	Sector 5 is situated in Safety Bay, bound onshore by Mersey Point and the submerged stable sandbar adjacent to Berry Street. The shoreline of Sector 5 corresponds to Secondary Cell 13A from the Vlamingh Coast (Stul et al, 2015). Sector 5 includes the Tern Bank Sandbar and Carlisle and Bent Street Boat Launching Facilities.
Land use	Foreshore parks with a combination of natural and built elements, boating facilities, residential and commercial.
Adaptive pathway (beyond 2030)	Long term protection as per CHRMAP
Coastal processes	
Exposure	Low-medium energy wave climate, sheltered from northerly events. Generally exposed to the south-westerly Seabreeze and fetch over the Warnbro Sound, with the exception of calm waters in the lee of Tern Bank Sandbar.
Sediment dynamics	There is a large sediment feed which comes ashore at the northern end of Warnbro Sound, in the lee of First, Second, Third and Passage Rocks. As a result of the sand feed, areas of significant accretion exist, including the Tern Bank Sandbar, which is estimated to be accreting at an average rate of 12,000m3 per year while simultaneously moving in a south-easterly direction at an average rate of around 30m to 40m per year. The growth of Tern Bank has led to siltation of the Bent Street Boat Ramp navigation channel. The large sediment feed from Penguin Island also supplies sand to this Sector which is likely to have contributed to the growth of Tern Bank Sandbar and the accretion fronting the Carlisle Street Boat Ramp. The offshore sand feeds and subsequently the Tern Bank Sandbar are very dynamic features and the future of such features is not well understood.
Vulnerability to erosion	2030 erosion hazard line suggests shoreline recession of up to 170m within Sector. Infrastructure and amenities including Safety Bay foreshore car parks are situated within extent of 2030 erosion hazard line. Refer CHRMAP for definition.
Vulnerability to inundation	Low lying land along the Safety Bay foreshore is susceptible to coastal inundation. Refer CHRMAP for definition.
Land tenure	
Shoreward	The Sector is managed by the City of Rockingham.
Seaward	The offshore water body is characterised by the Shoalwater Islands Marine Park General Use Zone which extends from the low-water mark offshore. The 52-hectare Second Rock Sanctuary Zone lies within the nearshore waters of the Sector.
Social and recreational value	Sector 5 is a high use area for recreational boating access to the Marine Park and the deeper waters of the Warnbro Sound. The foreshore area is an active recreational zone for walking, BBQ's and picnics and the Pond, in the lee of Tern Bank Sandbar is a popular location for kitesurfing. The Pond foreshore area, located within Sector has been defined in the City's Foreshore Master Plan as a focus area for the development of events.
Environmental value	Fringing the Shoalwater Islands Marine Park, the Sector is a key area of environmental value. There is a high density of nearshore seagrass habitats. The Second Rock Sanctuary Zone offshore from the Sector includes areas of seagrass, sand and subtidal macroalgae dominated reef (high and low profile) communities which provides a scientific reference site that could be used for monitoring issues such as water quality and edge effects of sanctuary zones.

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Sector 5 - Safety Bay

FIGURE 8-1

Cardno

Map Produced by Cardno (WA) Pty Ltd
Date: 2019-11-25
Coordinate System: GDA 1994 MGA Zone 50
Project: GV108200
Map: Figure 8-1_Sector 5 02.mxd 01
Imagery: Nearmaps.com (October 2019)

8.2 Key Management Issues

> S5-01: Loss of beach widths along Safety Bay foreshore

> S5-02: Loss of Safety Bay foreshore car park infrastructure

> S5-03: Navigational safety implications associated with the siltation of Bent Street navigation channel

> S5-04: OpEx implications associated with the siltation of Bent Street navigation channel

> S5-05: Approval process implications associated with sand extraction from Bent Street navigation channel and head of Tern Bank Sandbar

> S5-06: Approval process implications associated with re-use of material extracted from Bent Street navigation channel and head of Tern Bank Sandbar

> S5-07: Community acceptance implications associated with re-use of material extracted from Bent Street navigation channel and head of Tern Bank Sandbar

> S5-08: Inadequate boat ramp infrastructure within Sector

> S5-09: Inadequate maritime infrastructure within Sector

> S5-10: Inadequate car and boat trailer parking infrastructure within Sector

> S5-11: Potential loss of tourism due to natural progression of the Pond

> S5-12: Potential reduction of water quality due to natural progression of the Pond

8.3 Option Definition

8.3.1 Option 1 – Status quo

The status quo option incorporates the continual operation and maintenance of current assets within the Sector, including maintenance excavation of the Bent Street Boat Ramp navigation channel to manage:

a. The accretion of sand at the head of the Tern Bank Sandbar every year; and

b. The residual siltation in the channel less frequently.

The status quo option also continues the current operation of Carlisle Street, Bent Street and Donald Drive boat ramps with no proposed upgrades over the study's planning horizon. Amongst the issues detailed in Section 8.2, the status quo for Sector 5 is constrained by shortfalls in recreational boating facilities, exacerbated due to the popularity of the area for boat users and the long-term jeopardy of the Pond.

The section of Safety Bay foreshore within the study area contains three of Rockingham's six boat launching facilities, all of which are located within a 2km stretch of shoreline. Release of the Draft Safety Bay and Shoalwater Foreshore Master Plan in September 2019 has reiterated the City's intentions to maintain and develop the Pond as a key area for kite surfing amenities. In order to align with the City's intentions for the Pond, the natural progression of Tern Bank needs to be interrupted. The natural progression of the Tern Bank is detailed in the Literature Review in **Appendix A**.

The Tern Bank Sandbar offers protection to Bent Street Boat Ramp against the Seabreeze. As a result, Bent Street Boat Ramp is one of the few locations within Rockingham where major upgrade works would likely not warrant breakwater protection to reduce wave agitation at facility. Although Tern Bank Sandbar offers protection against wave energy, the feature is highly dynamic and subject to seasonal and interannual change. 10-year mapping of the vegetation line (**Figure 8-1**) shows the feature has undergone significant accretion at the head, while simultaneously eroding along a central section. The Bent Street Boat Ramp, the Pond and adjacent amenities are all reliant on the existence of the Tern Bank Sandbar and as such, it is important that the City seek to better understand the dynamics of this feature.

8.3.2 Option 2 – Stabilise Tern Bank with terminal groyne and sand trap management (local)

Option 2 incorporates the use of geotextile sand containers to construct a 200m length of seawall at the head of Tern Bank and a 50m length of terminal groyne which runs parallel to the current navigation channel (**Figure 8-2**). The works are intended to provide localised stabilisation to the head of Tern Bank to prevent further growth of the Sandbar and trap sand prior to entering the navigation channel. The option is also intended to maintain the Pond as an open water body for water quality flushing and future kite surfing opportunities in alignment with the Draft Safety Bay and Shoalwater Foreshore Master Plan. Due to the dynamic nature and sensitivity of Tern Bank Sandbar and offshore sand feeds, the construction of localised protection structures needs to be carefully considered. It is proposed that subsequent to the stabilisation works, Bent Street Boat Ramp be upgraded to cater for the future demand for boat launching facilities.

Construction of the terminal groyne is anticipated to provide 20,000m^3 of sand storage capacity in the groyne's lee prior to bypassing into the navigation channel. Based on the anticipated additional storage, it is estimated that the groyne will become saturated in approximately 2 years post construction. To account for the vulnerability of the Tern Bank, it is proposed that once the groyne becomes saturated, sand accrued in the structure's lee be periodically extracted and placed on Tern Bank both to prevent bypassing of the littoral drift into the navigation channel and reinforce the feature both laterally and vertically. Regular maintenance dredging of the navigation channel is also expected to continue to manage residual siltation in the channel, similar to current practice Option 1 – status quo (section 8.3.1, b).

It is proposed a placement plan be developed to coincide with this option with consideration of the material, placement location and placement method. It is likely that the material accrued in the lee of the proposed groyne will comprise of similar characteristics to the material currently extracted from the head of Tern Bank Sandbar and Bent Street Boat Ramp navigation channel. It is understood that the local beach subsurface sand layer may contain darker coloured sand with a high amount of organic matter, so the placement method shall prioritise the layering of the lighter coloured sand on top and incorporate a vegetation strategy to ensure adequate stabilisation and blending of the relocated material in the natural environment. The re-use of this material within the same sediment cell as it is extracted from is anticipated to lessen the current burden on City to find appropriate disposal locations outside of the sediment cell. It is proposed a placement plan be developed to coincide with this option, which will require approval from DBCA Swan Coastal District for placement of material on Tern Bank.

The option proposes geotextile sand containers as opposed to rock due to the minimised visual impact and reduced potential for injury and equipment damage for kite surfers. Subject to sand compatibility, the use of geotextile sand containers may be constructed using sand extracted from a maintenance campaign on the Bent Street Boat Ramp navigation channel and Tern Bank.

Figure 8-2 Sector 5: Option 2 – Stabilise Tern Bank with terminal groyne and sand trap management (local)

8.3.3 Option 3 – Stabilise Tern Bank with seawall and terminal groyne and sand management (local)

Option 3 incorporates the geotextile sand container terminal groyne at the head of Tern Bank as per option 2 and a 900m length of geotextile sand container seawall along Tern Bank Sandbar (**Figure 8-3**). This option is intended to provide stabilisation to the head of Tern Bank to prevent further growth and manage the effects of secondary dynamics upstream of the seawall. As with Option 2, the terminal groyne is likely to require maintenance to mitigate bypassing sand upon saturation of the groyne. The construction of the terminal groyne enables management to be undertaken without impacting the operation of the navigation channel. Due to the orientation of Tern Bank and the protection it offers Bent Street Boat Ramp, it is proposed that subsequent to the stabilisation works, Bent Street Boat Ramp be upgraded to cater for the future demand for boat launching facilities.

Consistent with Option 2, Construction of the terminal groyne is anticipated to provide 20,000m^3 of sand storage capacity in the groyne's lee prior to bypassing into the navigation channel. Based on the anticipated additional storage, it is estimated that the groyne will become saturated in approximately 2 years post construction. It is proposed that once the groyne becomes saturated, sand accrued in the structure's lee be periodically extracted and placed on Tern Bank in the rear of the proposed seawall to reinforce the feature both laterally and vertically. It is proposed a placement plan be developed to coincide with this option, which will require approval from DBCA Swan Coastal District for placement of material on Tern Bank.

Figure 8-3 Sector 5: Option 3 – Stabilise Tern Bank with seawall and terminal groyne and sand management (local)

8.3.4 Option 4 – Tern Bank natural progression with realigned channel parallel to coast nearshore

Option 4 allows the natural progression of Tern Bank in a south-easterly direction until it reconnects with the shoreline between the locations of the Bent Street and Donald Drive boat launching facilities (**Figure 8-4**). Based on the progression of the Sandbar over the past 10 years, it is not unreasonable to assume this phenomenon could occur within the 10-year planning horizon of this Study. In the interim, this option proposes the current maintenance works to the navigation channel and the head of Tern Bank be discontinued and a new channel be dredged and maintained along the alignment of the nearshore natural channel which runs parallel to the shoreline. Key implications associated with the natural progression of Tern Bank include water quality issues in the Pond due to the absence of natural flushing and the foreseen closure of Bent Street boat launching facilities. The Department of Transport are also unlikely to support the operation of a navigation channel in such close proximity to the shoreline due to safety implications with land users.

Figure 8-4 Sector 5: Option 4 – Tern Bank natural progression with realigned channel parallel to coast nearshore

8.3.5 Option 5 – Carlisle Street Upgrade - Allow Bent Street to close

Option 5 incorporates the upgrade of Carlisle Street Boat Ramp into a formal facility to regulatory standard (**Figure 8-5**). Due to the exposure or the ramp to the south-westerly sea breeze, it is likely that breakwater protection will be required to allow the safe launching and retrieval of vessels. The upgrade works will enable Bent Street Boat Ramp to close and maintenance works at Tern Bank to discontinue or be reduced only to the degree required to maintain the Pond. Littoral drift of sand in the vicinity of breakwater protection at Carlisle Street would likely require ongoing management to cater for sand build up upstream and erosion downstream of the facility.

Figure 8-5 Sector 5: Option 5 – Carlisle Street Upgrade - Allow Bent Street to close

Table 8-2 Sector 5 – Option definition

Sector 5 – Safety Bay	Option 1 - Status quo								Option 2 - Stabilise Tern Bank with terminal groyne and sand trap management (local)								Option 3 - Stabilise Tern Bank with seawall and terminal groyne and sand management (local)								Option 4 - Tern Bank natural progression with realigned channel parallel to coast nearshore								Option 5 - Carlisle Street Upgrade - Allow Bent Street to close							
	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose
Seawall - Tern Bank head													17								22																	
Groyne - Tern Bank													18								18																	
Breakwater and revetment (boating)	1								1								1								1								1				25			
Sand trap										20		20						20		20																		
Sand storage area																																							
Navigation channel - Bent Street	2	3	4	5			6	7	2	3	4	5			6	7	2	3	4	5			6	7	2		4	5			6	7	2	3	4	5			6	7
Navigation channel - New																										24			23								25			
Boat ramp - Carlisle Street	8	9							8	9							8	9							8	9							8	9						
Boat ramp - Bent Street	10	12							10	12	19						10	12	19						10	12							10	12						
Boat Ramp - New																																							
Boating facility Maritime structures	11	12							11	12	19						11	12	19						11	12							11	12			25			
Sand supply (Natural - Feeds and banks)	13	3		5			6	7	13	3		5, 21			6	7	13	3		5, 21			6	7	13	3		5			6	7	13	3		5			6	7
Natural amenity (beach, reserve)		14		5						14		5						14		5						14		5						14		5				
Parking - Carlisle Street	15	9							15	9							15	9							15	9							15	9			25			
Parking - Bent Street	16								16		19						16		19						16								16							

[1] Formal rock revetments on either side of Bent Street Boat Ramp.

[2] Bent Street Boat Ramp navigation channel, originally dredged in 2014 to allow access to and from the ramp.

[3] Maintenance work is currently undertaken on the Bent Street Boat Ramp Navigation Channel. A campaign was undertaken in October 2019 with a budget of $427,000 which included maintenance within the navigation channel and at the head of Tern Bank. The $427,000 included excavation and disposal. The maintenance work generally includes the removal of 15,000m3 of sand in total. 5,000-8,000m3 of this is from the navigation channel itself and 7,000-10,000m3 of this is from the head of Tern Bank.

October 2016/ January 2017 Campaign - Cutter Suction Dredging of Navigation Channel/Tern Bank -17,500m3 of 25,000m3 achieved due to delays with wire weed blockages. Placement of dredged material on adjacent Safety Bay Foreshore.

Dec 2018 Campaign - Long Reach Excavation from Tern Bank Sandbar, (10,000m3) Off-Road Dump Trucks hauled material to Carlisle Street Boat Ramp. Truck transport to Apex for beach renourishment. Works suspended in Feb 2019 due to sand discolouration. Sand trucked to landfill in August 2019. The Cost associated with the 2018 campaign were $219k, which included excavation and transport to Apex + $80k transportation of material to landfill in Aug 2019.

September/ October 2019 Campaign - Long Reach Excavation from Tern Bank Sandbar (15,000m3+5,000m3 variation to works). Dredged material trucked to landfill facility. The Cost was $427,000.

[4] A cutter suction dredge campaign is planned for March/ April 2020 to extract 10,000m3 of sand from within the Bent Street Navigation Channel. This is a "one off" campaign and is not part of the routine maintenance undertaken by the City. A budget for Bent Street Navigation channel maintenance dredging channel siltation of $390,000 every 4 years is assumed. This is subject to unknown impacts of future sediment transporting into the Navigation Channel from the southern end of the channel. More frequent maintenance may be required if the deep-water channel undergoes more rapid changes especially where sand covers seagrass meadows.

[5] Monitoring in the form of profile surveys is undertaken biannually on the navigation channel, Tern Bank and the foreshore adjacent to Bent Street Boat Ramp. The monitoring budget is $15,000 per year.

[6] The sand extracted from the Bent Street Navigation Channel and the head of Tern Bank has historically been used for renourishment on 2 occasions. The first was used to renourish the beach south of Bent Street Boat Ramp which received two formal complaints regarding the colour of the sand. The second was deposited adjacent to Donald Drive and further south which received significant backlash by the community on the colour of the sand.

[7] Due to the reluctance of reusing the sand extracted from Bent Street Navigation Channel and the head of Tern Bank for nourishment, recently the extracted material has been taken to landfill. Landfill is a 29km round trip from Bent Street.

[8] Carlisle Street Boat Ramp is an informal over sand ramp located approximately 1km to the west of Bent Street Boat Ramp.

[9] The City currently has a budget of $55,000 for the maintenance of sea wrack and sand accrual at Carlisle Street Boat Ramp and car park. These works are undertaken based on an internal trigger system at the City.

[10] Bent Street Boat Ramp consists of 2 concrete ramps separated by a finger jetty, additional over-beach ramps are located on either side of the facility.

[11] Bent Street Boat Ramp finger jetty and associated maritime structures.

[12] The City undertook maintenance on the Bent Street Boat Ramp maritime facilities in 2015/ 2016. The works included upgrades to the protection rock and the redesign and replacement of fenders. The Bent Street Boat Ramp maintenance budget is $35,000 annually.

[13] Tern Bank Sandbar

[14] Sand back passing has historically been undertaken on two occasions using sand extracted adjacent to Carlisle Street Boat Ramp and deposited on the eroding section of beach at Mersey Point.

[15] 15 formal boat trailer parking bays at Carlisle Street Boat Ramp.

[16] 11 formal car only parking bays and 22 formal boat trailer parking bays at Bent Street Boat Ramp.

[17] Construct approximately 200m length of geotextile sand container seawall to stabilise the head of Tern Bank. Construction to be undertaken as part of an annual dredging campaign and along the alignment of the City's excavation licence boundary.

[18] Construct one approximately 50m length of geotextile sand container groyne at the eastern extent of the new seawall. Groyne to be constructed parallel to the alignment of the Bent Street Boat Ramp navigation channel.

[19] Subsequent to the construction of the geotextile container seawall and groyne on Tern Bank Sandbar, plan to upgrade/ build new boat ramps, maritime structures and parking facilities to cater for future demand.

[20] Subsequent to the construction of the geotextile container seawall and groyne on Tern Bank Sandbar, develop a sand management plan for the extraction of the sand trap (upstream of the geotextile sand container groyne) and disposal on Tern Bank and surrounds to build the Sandbar both vertically and laterally.

[21] In addition to existing monitoring of the Bent Street Boat Ramp navigation channel, Tern Bank and the foreshore adjacent to Bent Street Boat Ramp, develop a monitoring program for the Tern Bank offshore sand feed.

[22] Construct approximately 900m length of geotextile sand container seawall to stabilise the head and seaward extent of Tern Bank.

[23] Construct a new nearshore navigation channel to Bent Street Boat Ramp aligned parallel to the coastline.

[24] Subsequent to the construction of the new navigation channel, develop a dredge management plan to maintain safe navigation depths.

[25] Construct a new maritime facility including breakwater protection, navigation channel, ramp infrastructure, maritime structures and car and boat trailer parking at Carlisle Street Boat Ramp. Including associated design, environmental planning, construction, maintenance, monitoring and sand management accosted with the development of the new facility.

8.4 Multi-criteria Assessment

Table 8-3 Sector 5 – Multi-criteria assessment

Sector 5 – Safety Bay		Option 1 - Status quo		Option 2 - Stabilise Tern Bank with terminal groyne and sand trap management (local)		Option 3 - Stabilise Tern Bank with seawall and terminal groyne and sand management (local)		Option 4 - Tern Bank natural progression with realigned channel parallel to coast nearshore		Option 5 - Carlisle Street Upgrade - Allow Bent Street to close	
Technical feasibility	Performance	3	– Baseline performance	4	– Offer partial erosion protection by reusing sand in sediment cell – Reduces siltation of dredged channel	5	– Fully addresses the risk of sand bar breaching under extreme events – Reduces siltation of dredged channel	1	– Deteriorating water quality in the Pond – Natural flushing impaired – Stormwater management issues – Loss of boating facility post closure	3	– Addresses boat ramp capacity issues and maintenance issues associated with Tern Bank – Likely secondary effects with sand accretion upstream
	Safety	3	– Baseline Safety – Assumed navigation channel is maintained prior to safety implications arising	3	– Assuming maintenance is upkept	3	– Assuming maintenance is upkept	1	– Navigation too close to the shoreline and public users	2	– Assuming maintenance is upkept at Carlisle, however safety issues could arise during closure of Bent Street ramp
Economic viability	CapEx	5	– Baseline for Mersey Point Seawall works: – New wall: $750,000 (based on $7,500/m *100m length) – Upgraded temporary seawall: $250,000 – Total: $1,000,000	3	– Baseline for Mersey Point Seawall works: $1,000,000 plus: – Tern bank head protection GSC seawall (220m length at $7,500/m): $1,650,000 – Tern Bank terminal groyne GSC seawall (50m length at $10,000/m): $375,000 – Total: $3,025,000	1	– Baseline for Mersey Point Seawall works: $1,000,000 plus: – Tern bank along spit protection GSC seawall (780m length at $7,500/m): $5,850,000 – Tern bank head protection GSC seawall (220m length at $7,500/m): $1,650,000 – Tern Bank terminal groyne GSC (50m length at $10,000/m): $375,000 – Total: $8,875,000	4	– Baseline for Mersey Point Seawall works: $1,000,000 plus: – Navigation channel: $650,000 (based on $650,000 for 25*250m channel - CoR provided) – Total: $1,650,000	2	– Baseline for Mersey Point Seawall works: $1,000,000 plus: – Navigation channel: $650,000 (based on $650,000 for 25*250m channel - CoR provided) – Rock breakwaters: 2 arms (100m + 50m at $15,000/m) total of $2,250,000 – No Reclaimed land – Additional car park: $1,300,000 – Jetty & Ancillary Facilities $3,500,000 – Total: $8,700,000
	OpEx (eq. based on NPV10 and CapEx)	2	– Bent Street Navigation channel maintenance excavation Tern Bank accretion (20,000m3/year): $490,000/year – Bent Street Navigation channel maintenance dredging channel siltation (10,000m3 /4years): $390,000 /4 year starting in year 4 – Baseline for Mersey Point Seawall works (assume 50% of CapEx every 40years) New wall: $375,000 Upgraded temporary seawall: $125,000 – Carlisle Street maintenance: $55,000/year – Bent Street maintenance: $35,000/year	3	– Sand trap maintenance (20,000m3, local): $180,000/year starting in year3 – Bent Street Navigation channel maintenance dredging channel siltation (10,000m3 /4years): $390,000 /4 year starting in year 4 – Mersey Point Rock Seawall works (assume 50% of CapEx every 40years) New wall: $375,000 Upgraded temporary seawall: $125,000 – Tern Bank GSC seawall works (assume 50% of CapEx every 15years) Terminal groyne: $187,500 Seawall - Head: $825,000 – Carlisle Street maintenance: $55,000/year – Bent Street maintenance: $35,000/year	3	– Sand trap maintenance (20,000m3, local): $180,000/year from year3 – Bent Street Navigation channel maintenance dredging channel siltation (10,000m3 /4years): $390,000 /4 year starting in year 4 – Mersey Point Rock Seawall works (assume 50% of CapEx every 40years) New wall: $375,000 Upgraded temporary seawall: $125,000 – Tern Bank GSC seawall works (assume 50% of CapEx every 15years) – Terminal groyne: $187,500 – Seawall - Head: $825,000 – Seawall - Along Spit: $2,925,000 – Carlisle Street maintenance: $55,000/year – Bent Street maintenance: $35,000/year	4	– Bent Street Navigation channel maintenance dredging channel siltation (10,000m3 /4years): $390,000 /4 year starting in year 4 – Mersey Point Rock Seawall works (assume 50% of CapEx every 40years) – New wall: $375,000 – Upgraded temporary seawall: $125,000 – Carlisle Street maintenance: $55,000/year – Bent Street maintenance: $35,000/year	5	– Navigation channel maintenance dredging channel siltation (10,000m3 /4years): $390,000 /4 year starting in year 4 – Rock breakwaters (assume 50% of CapEx every 40years): $1,125,000 – Mersey Point Rock Seawall works (assume 50% of CapEx every 40 years) – New wall: $375,000 – Upgraded temporary seawall: $125,000 – Car park and NO reclaim (assume 50% of CapEx every 40years): $650,000 – Jetty and Ancillary Facilities (assume 50% of CapEx every 40years): $1,750,000 – Carlisle Street maintenance: $55,000/year from year 3
	NPV10	3	– $6,750,000	4	– $5,710,000	1	– $11,560,000	5	– $3,110,000	2	– $9,750,000

Environmental and social desirability	Impact	3	– Baseline impact Mersey Point seawall works – Bent Street navigation channel Tern bank extraction works	3	– Mersey Point seawall works – Terminal groyne and seawall works – Sand extraction and maintenance works at new GSC groyne – Unknown impact to Tern Bank	3	– Mersey Point seawall works – Terminal groyne and seawall works – Tern bank seawall works – Sand extraction and maintenance works at new GSC groyne	3	– Deteriorating water quality in the Pond.	1	– Mersey Point seawall works – Carlisle Street upgrade works – Sand extraction and maintenance works at new Breakwater structure – New dredged channel works
	Regulation	3	– Baseline approvals – Mersey Point seawall works approvals – Bent Street navigation channel Tern bank extraction works approvals	4	– Mersey Point seawall works – Terminal groyne and seawall works approvals – Sand extraction and maintenance works at new GSC groyne approvals	4	– Mersey Point seawall works – Terminal groyne and seawall works approvals – Tern bank seawall works approvals – Sand extraction and maintenance works at new GSC groyne approvals	1	– DoT unlikely to approve realignment of navigation channel due to safety implications with adjacent foreshore users	2	– Onerous approvals associated with new marina in Shoalwater Islands Marine Park
	Public acceptance	3	– Baseline acceptance	3	– Maintained functionality of the Pond – Maintained functionality of Bent Street Boat Ramp – Maintained visual amenity of Tern Bank sandbar – Potential for seagrass accrual in lee of groyne and public acceptance issues – Potential for variation to Tern Bank footprint and public acceptance issues	4	– Maintained functionality of the Pont – Maintained functionality of Bent Street Boat Ramp – Maintained visual amenity of Tern Bank sandbar – Potential for seagrass accrual in lee of groyne and public acceptance issues	1	– Incompatible with masterplan for the Pond – Likely public acceptance issues associated with the water quality of the Pond	1	– Incompatible with masterplan for the Pond – Likely public acceptance issues associated with the water quality of the Pond – Major visual amenity reduction potentially leading to public acceptance issues with new marina structure fronting residential area instead of beach
	Independent operation from adjacent coastal managers	3	– Baseline operation	3	– No change from baseline	3	– No change from baseline	3	– No change from baseline	3	– No change from baseline
TOTAL SCORE		**28**		**30**	**Preferred option**	**27**		**23**		**21**	**Least preferred**

8.5 Sensitivity

Sensitivity analysis of sub-criteria weightings has been undertaken to account for stakeholder ambiguity. The results of the analysis are presented in **Figure 8-6** below. The results suggest that the equal weighting of sub-criteria adopted in the MCA process provide a satisfactory indication of the preferred option under various distributions of weightings. In this case, Option 2 is clearly the most preferred option.

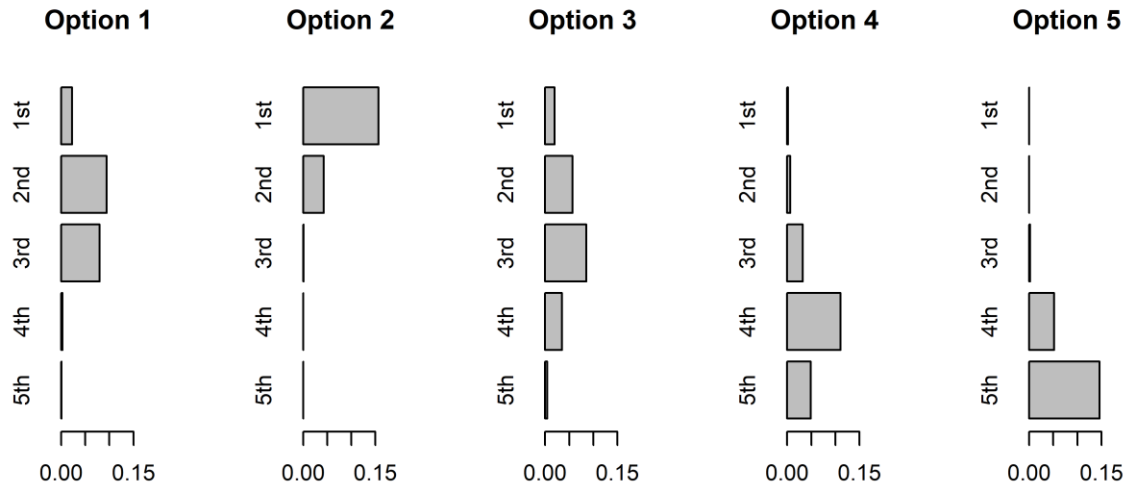

Figure 8-6 Sector 5 sensitivity analysis

8.6 Preferred Option

The preferred option for Sector 5 is *Option 2 – Stabilise Tern Bank with terminal groyne and sand trap management (local).* The option involves the construction of approximately 200m length of geotextile sand container seawall at the head of Tern Bank and a 50m length of terminal geotextile sand container groyne which runs parallel to the current navigation channel

8.6.1 Benefits

- Offers partial erosion protection by reusing sand within sediment cell;
- Reduction in operational expenditure between 0-3 years;
- Reduction in NPV10 by 15% or approximately ~$1million from status quo;
- Potentially less onerous approval requirements due to reduced management footprint and more controlled system within the dedicated sand trap; and
- Improved stability of the Tern Bank through stabilising works, strategic sand placement and maintaining sand locally within sediment cell.

8.6.2 Trade-offs (risks and limitations)

- Requires coordination with key stakeholders and ongoing agreement between the City of Rockingham and Department of Biodiversity, Conservation and attractions;
- Capital expenditure associated with construction of retaining structures;
- Risk of destabilisation of Tern Bank is still partially present;
- Ongoing sand management is required to keep sand from bypassing groyne and maintaining the sand on Tern Bank; and
- GSC material maintenance requirements kicks in after 15 years, as opposed to 40 years for rock.

8.6.3 Long-term adaptive pathway

The long-term adaptive pathway for the sector, as defined in the CHRMAP is 'Protect'. While the preferred option aligns with the City's strategic direction for the Sector, the proposed stabilisation works for Tern Bank are not intended as shoreline protection measure against the natural long-term erosion risk highlighted in the CHRMAP. Rather, the proposed works are recommended as coastal management measures with key operational functions in the near-to mid-term by maintaining and enhancing amenities and coastal values, while likely increasing resilience. The preferred option does not remove the need to develop a longer-term protection scheme for coastal erosion and inundation.

8.6.4 Implementation timeframe

The Tern Bank Sandbar is a highly dynamic feature which relies on the presence of offshore sand bars. As such, the future of Tern Bank is not well understood. It is recommended that detailed coastal process simulations be undertaken on Tern Bank prior to the construction of any protective structures. It is reasonable to assume that the studies required to feed the proposed works could take 2 years. Given the planning and environmental approvals required for the works. It is suggested that the implementation of the preferred option would fall in the mid-term planning horizon of 4-10 years.

9 Sector 6 – Warnbro Sound

9.1 Sector Profile

Table 9-1 Profile – Sector 6: Warnbro Sound

Profile	Definition
Location	Sector 6 is situated in the north of Warnbro Sound and is bound onshore by the submerged stable sandbar adjacent to Berry Street and Donald Drive Boat Ramp. The shoreline of Sector 6 corresponds to the northern portion of Secondary Cell 12A from the Vlamingh Coast (Stul et al, 2015). Sector 6 includes the Donald Drive Boat Launching Facilities.
Land use	Foreshore parks with a combination of natural and built elements, boating facilities, residential and commercial.
Adaptive pathway (beyond 2030)	Long term protection as per CHRMAP
Coastal processes	
Exposure	Low-medium energy wave climate, sheltered from northerly events. Exposed to the south-westerly Seabreeze and fetch over Warnbro Sound.
Sediment dynamics	There is an offshore sand feed to the north of this Sector which comes ashore in the lee of First, Second, Third and Passage Rocks. The sand feed has resulted in the development of the submerged sandbar adjacent to Berry Street is a relatively stable feature. Sand fed onshore is transported in a net south-easterly direction along the shoreline. The beach drops off relatively quickly into the deeper waters of the Warnbro Sound.
Vulnerability to erosion	2030 erosion hazard line suggests shoreline recession of up to 170m within Sector. Infrastructure and amenities including Safety Bay foreshore car parks are situated within extent of 2030 erosion hazard line. Refer CHRMAP for definition.
Vulnerability to inundation	Low lying land along the Safety Bay foreshore is susceptible to coastal inundation. Refer CHRMAP for definition.
Land tenure	
Shoreward	The Sector is managed by the City of Rockingham.
Seaward	The offshore water body is characterized by the Shoalwater Islands Marine Park General Use Zone which extends from the high-water mark offshore.
Social and recreational value	Sector 6 is a high use area for recreational boating access to the Marine Park and the deeper waters of the Warnbro Sound. The foreshore area is an active recreational zone for walking, BBQ's and picnics.
Environmental value	Fringing the Shoalwater Islands Marine Park, the Sector is a key area of environmental value. There is a high density of nearshore seagrass habitats.

city of Rockingham
where the coast comes to life

N

1:4,000 Scale at A3

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0 37.5 75 150

Sector 6 - Warnbro Sound

FIGURE 9-1

Cardno

Map Produced by Cardno (WA) Pty Ltd
Date: 2019-11-25
Coordinate System: GDA 1994 MGA Zone 50
Project: CW108000
Map: Figure 9-1_Sector 6 02.mxd 01
Imagery: Nearmaps.com (October 2019)

9.2 Key Management Issues

> S6-01: Loss of beach widths along Safety Bay foreshore

> S6-02: Loss of Safety Bay foreshore car park infrastructure

> S6-08: Inadequate boat ramp infrastructure within Sector

> S6-09: Inadequate maritime infrastructure within Sector

> S6-09: Inadequate car and boat trailer parking infrastructure within Sector

9.3 Option Definition

9.3.1 Option 1 – Status quo - Maintain Bent Street and Donald Drive facilities

The status quo option is a continuation of the current coastal management works undertaken by the City in this Sector. This includes ad-hoc sea wrack removal campaigns at Donald Drive Boat Ramp under the City's discretion. This option also incorporates the continued operation of Donald Drive Boat Ramp as an informal over-sand facility.

9.3.2 Option 2 - Close Bent Street facilities and Upgrade Donald Drive facility

Option 2 incorporates the upgrade of Donald Drive Boat Ramp into a formal facility to regulatory standard (**Figure 9-2**). Due to the exposure or the ramp to the south-westerly sea breeze, it is likely that breakwater protection will be required to allow the safe launching and retrieval of boats. The upgrade works will enable Bent Street Boat Ramp to close and maintenance works at Tern Bank to discontinue or be reduced only to the degree required to maintain the Pond. Littoral drift of sand in the vicinity of breakwater protection at Donald Drive would likely require ongoing management to cater for sand build up upstream and erosion downstream of the facility.

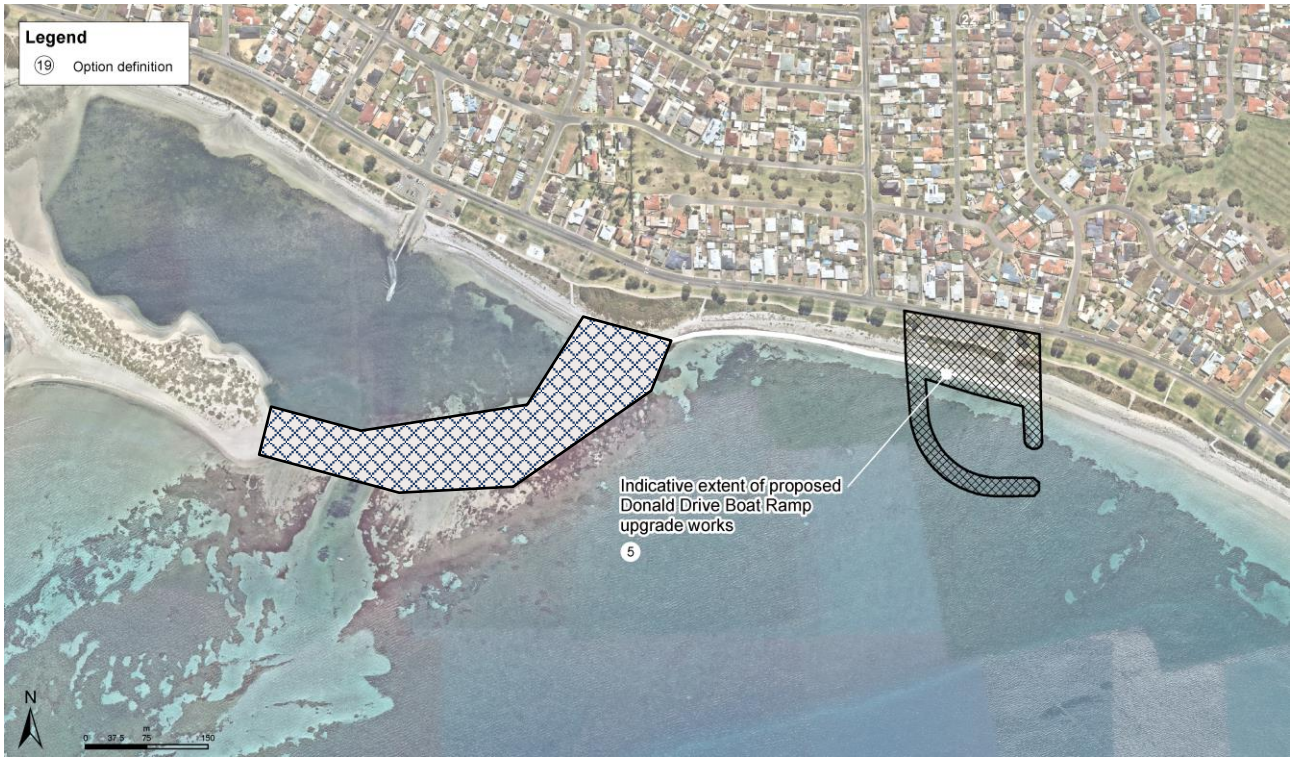

Figure 9-2 Sector 6: Option 2 – Donald Drive Upgrade

Table 9-2 Sector 6 – Option definition

Sector 6 – Warnbro Sound		Option 1 - Status quo - Maintain Bent Street and Donald Drive facilities								Option 2 - Close Bent Street facilities and Upgrade Donald Drive facility							
		Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose	Existing	Maintain	Plan	Monitor	Build New	Upgrade	Reuse	Dispose
Assets	Breakwater and revetment (boating)													5			
	Navigation channel - New													5			
	Boat ramp - Donald Drive	1	2							1	2			5			
	Boating facility Maritime structures													5			
	Sand trap																
	Sand supply (Natural - Feeds and banks)	3								3							
	Natural amenity (beach, reserve)																
	Parking - Donald Drive	4								4				5			

[1] Donald Drive Boat Ramp consists of an informal over sand ramp located approximately 750m to the east of Bent Street Boat Ramp.

[2] The City currently undertakes maintenance work at Donald Drive Boat Ramp to remove sea wrack as part of a maintenance program which incorporates three cells from the Pond to Waikiki. Approval has been granted by DBCA for the City to remove sea wrack at the City of Rockingham's discretion. Maintenance work is carried out using a tractor and profiling the beach 20m either side of ramp.

[3] Submerged stable sandbar located east of Tern Bank Sandbar.

[4] 15 formal boat trailer parking bays and 9 formal car only parking bays at Donald Drive Boat Ramp. These were upgraded in 2017.

[5] Construct a new maritime facility including breakwater protection, navigation channel, ramp infrastructure, maritime structures and car and boat trailer parking at Donald Drive Boat Ramp. Including associated design, environmental planning, construction, maintenance, monitoring and sand management accosted with the development of the new facility.

9.4 Multi-criteria Assessment

Table 9-3 Sector 6 – Multi-criteria assessment

Sector 6 – Warnbro Sound		Option 1 - Status quo - Maintain Bent Street and Donald Drive facilities		Option 2 - Close Bent Street facilities and Upgrade Donald Drive facility	
Technical feasibility	Performance	3	– Baseline performance	2	– Improved boat ramp capacity and management issues associated with Tern Bank and Bent Street Navigation Channel – Likely secondary effects of sand build up upstream of new breakwater and erosion downstream – Deteriorating water quality in the Pond. Natural flushing impaired. Stormwater management issues
	Safety	3	– Baseline Safety – Navigation channel is maintained prior to safety implications arising – Donald Drive is currently not an all-weather accessible boat ramp	4	– Allows launching and retrieving of boats in all weather
Economic viability	CapEx	5	– Baseline CapEx ($0)	1	– Navigation channel: $650,000 (based on $650,000 for 25*250m channel - CoR provided) – Rock breakwaters: 2 arms (100m + 150m at $15,000/m) total of $3,750,000 – Additional car park: $1,975,000 – Reclaimed land: 50x100m: $675,000 – Jetty & Ancillary Facilities $3,500,000 – Total: $9,875,000
	OpEx	3	– Bent Street Navigation channel maintenance excavation Tern Bank accretion (20,000m3/year): $490,000/year – Bent Street Navigation channel maintenance dredging channel siltation (10,000m3 /6years): $390,000 /6 year starting in year 6 – Donald Drive maintenance: $26,000/year	5	– Navigation channel maintenance dredging channel siltation (10,000m3 /6years): $390,000 every 6-year starting in year 6 – Rock breakwaters (assume 50% of CapEx every 40years): $1,875,000 – Car park and reclaim (assume 50% of CapEx every 40years): $987,5000 – Jetty and Ancillary Facilities (assume 50% of CapEx every 40years): $1,750,000 – Donald Drive maintenance: $26,000/year from year 3 – Sand and sea wrack management: Assume Tern Bank sandbar net movement south continues not affecting facility within 10 years
	NPV10	3	– $4,850,000	1	– $10,390,000
Environmental and social desirability	Impact	3	– Baseline impact – Regular Bent Street navigation channel Tern bank extraction works	1	– Mersey Point seawall works – Donald Drive upgrade works – Sand extraction and maintenance works at new Breakwater structure – New dredged channel works – Closure of the Pond WQ issues
	Regulation	3	– Baseline approvals – Bent Street navigation channel Tern bank extraction works approvals	1	– Onerous approvals associated with new marina in Shoalwater Islands Marine Park
	Public acceptance	3	– Baseline acceptance	1	– Major visual amenity reduction potentially leading to public acceptance issues with new marina structure fronting residential area instead of beach. – Likely public acceptance issues associated with the water quality of the Pond.
	Independent operation from adjacent coastal managers	3	– Baseline operation	3	– No change
TOTAL SCORE		**29**	**Preferred option**	**19**	**Least preferred option**

9.5 Sensitivity

Sensitivity analysis of sub-criteria weightings has been undertaken to account for stakeholder ambiguity. The results of the analysis are presented in **Table 9-3** below. The results suggest that the equal weighting of sub-criteria adopted in the MCA process provide a satisfactory indication of the preferred option under various distributions of weightings. In this case, Option 1 is clearly the most preferred option.

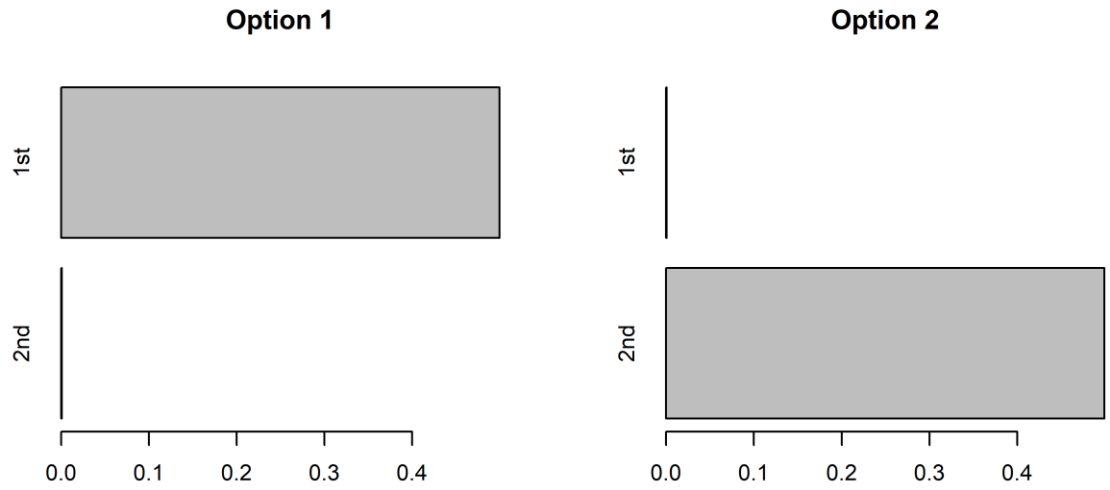

Figure 9-3 Sector 6 sensitivity analysis

9.6 Preferred Option

The preferred option for Sector 6 is *Option 1 – Status quo - Maintain Bent Street and Donald Drive facilities.* The option involves the continual management operations of the Sector in its current form. Specifically, the maintenance of Donald Drive Boat Ramp as an informal over-sand launching facility.

9.6.1 Benefits

- Lowest cost solution, zero capital expenditure and lowest NPV10;
- Baseline environmental impact and regulatory burden related to Bent Street Boat Ramp and Tern Bank maintenance requirements; and
- Maintains the Pond in accordance with the Safety Bay and Shoalwater Masterplan.

9.6.2 Trade-offs (risks and limitations)

- High operational expenditure associated with the ongoing maintenance at Bent Street Boat Ramp and Tern Bank;
- The City could reach a point where natural coastal processes accelerate or significant storm events drive higher sediment volumes into the channel and beyond. Should the City push over the sediment volume thresholds, DBCA may not authorise or renew future works and licences within Marine Park and Tern Bank Sandbar;
- Does not account for the shortfalls in boat launching capacity; and
- Continued wave agitation at Donald Drive Boat Ramp impacting the safe launching and retrieval of vessels.

10 Environmental Approval pathway

There are a number of statutory bodies and key stakeholders that are likely to be involved in the approvals process for the proposed works. These groups should be clearly identified as part of the design process.

The methodology to gain environmental approval for the preferred options (i.e. Sector 1 *Option 3 - Shift Spur Groyne northward* and Sector 5 *Option 2 - Stabilise Tern Bank with terminal groyne and sand trap management (local)* may depart from the usual Local Government approval pathways for the development of coastal protective structures and beach nourishment works.

For example, a Development Application (DA) would need to be lodged (preferably at detailed design stage) with the City for the proposed works, however it is recommended to discuss the proposed works with the City Planning Officers prior to lodging the DA to ensure that the key items are addressed. The Planning department will then advise if the proposed works are consistent with local planning guidelines and standards. The Planning Department will also advise if the proposed works are required to be referred to the EPA for State Government assessment under the EP Act.

The presence of potential sensitive areas adjacent to the proposed development site (e.g. Shoalwater Islands Marine Park and Garden Island Causeway) may increase the complexity of the approval process. It is therefore recommended to liaise with key stakeholders, including:

- City's Planning department;
- Department of Biodiversity and Conservation and Attraction (DBCA); and
- Department of Defense (DoD).

Early engagement with key stakeholders will be beneficial in a number of ways, including:

- Assist to accurately map out the required approvals process and ensures that appropriate and targeted stakeholder engagement can be undertaken well before construction activities are scheduled;
- Introduce the proposed development options to key stakeholders and receive their feedback and suggestions regarding their design and the applicable environmental approval framework;
- Identifying the appropriate level of approval requirements and expectations from statutory bodies and key stakeholders; and
- Assist to identify any major issues that could cause impacts on the project feasibility, timeframe or budget.

An accurate approvals pathway is difficult to determine at early concept engineering phase. The approach outlined above is a first step which is expected to facilitate the refinement of the design and fast track the environmental approval processes.

11 Summary and Conclusion

During the research, consultation and preparation of the Coastal Management Study Report, a range of issues and objectives were considered. These are summarised hereafter along with related outcomes and recommendations.

11.1 Impact of the sediment cells in the study area

Coastal management sectors have been defined and aligned with sediment cells to confine, as far as practicable, management activities within natural boundaries, where the movement of sediment is largely self-contained, notwithstanding that the shoreline dynamics can be uncertain due to significant offshore sand feed contributions (or lack thereof) to the littoral drift.

In this context and considering the limited amount of dedicated studies focusing on the local nearshore sediment dynamics, it is recommended to develop better integrated understanding of both the longshore and cross-shore sediment transport in the study area. This would be particularly valuable near very dynamic features such as Tern Bank Sandbar, where stability under ambient or extreme weather conditions is poorly understood.

11.2 Impact of climate change (in 10 years to 2030, in 30 years to 2050)

Climate change impact was considered in the Coastal Management Study, with due regard for the findings and recommendations outlined in the CHRMAP, such as long-term adaptation pathways across the various coastal management sectors.

Over the timeframe considered, one of the major risks identified in this coastal management study was related to the potential erosion of the Tern Bank Sandbar and its subsequent instability as a coastal barrier which supports strategic coastal attraction in the area including the Pond and Bent Street Boat Ramp. Despite its remarkable and rapid progression towards the south-east in the past, there is evidence indicating that the sand bank has been partially eroding over the past decade and that its cross section near the coast is thinning. This risk is only increasing as sea levels rise and mitigation should be put in place to address it.

There is also a significant risk of inundation in the study areas. This will become more critical in the future (beyond the 10-year study timeframe) as the sea level rise is expected to accelerate.

The proposed coastal management options are aligned with the long-term adaptation pathways outlined in the City's CHRMAP, however they may not be sustainable in the long-term. It is therefore recommended to review the performance of the coastal management options developed in this study regularly, as alternative solutions may become more attractive in the future, when climate change impacts are felt more acutely.

11.3 Impact of future sediment transport and activity on Tern Bank, the Pond and the Bent Street Boat Ramp

As outlined above, an erosion trend on a section of the Tern Bank Sandbar has been observed over the last decade. This raises some concerns about the stability of the bank in the near future, and the negative consequences on downstream amenities, such as the Pond and Bent Street Boat Ramp.

Although the coastal management activities taking place on Tern Bank Sandbar are not thought to directly contribute to this erosion trend, the removal of material from Tern Bank sediment cell is not recommended. In reality:

- It is strongly encouraged to maintain the sand within this sediment cell in a purposeful way, so as to build Tern Bank Sandbar's resilience to extreme erosion events.

Also, in the absence of coastal management activities on Tern Bank Sandbar:

- The natural closure of the Pond could be anticipated;
- The natural deterioration of water quality in the Pond, due to seagrass accumulation and decay, and other effluent and ground water discharges in the area, could accelerate; and
- The Bent Street Boat Ramp facility would need to close, as the accessibility to deep waters would be reduced to unsafe navigational depth.

Hence, coastal management activities on Tern Bank should not only be seen as an opportunity to manage coastal erosion more effectively but also elevated as a key strategic activity to be leveraged to reduce the vulnerability of the coastal amenities in this sector in the next 10 years.

11.4 Current and future demand for boat launching facilities

Currently, the capacity of recreational boat launching facilities in the study area is insufficient, as evident by large volume of overflow parking along the Safety Bay foreshore. This situation is unlikely to resolve naturally in the future as demand for boat launching facilities in Rockingham is anticipated to increase. Although the revised (yet to be issued) Department of Transport boating study has not yet been released to the public, it is understood that broad strategic recommendations will be made for additional boat ramps south of the Swan River. Taking the current and future demand into account and considering the high ratio of boat users in the Rockingham area, it is more likely than not that the study area would be a good location for additional boat launching facilities to address the future demand.

Furthermore, it was noted that current boat launching facility management activities may negatively impact users, community and the environment, particularly during maintenance dredging campaigns, where exclusion zones may be in place and local environmental disturbance are apparent.

It is therefore recommended to develop and evaluate coastal management options that not only maintain the boat launching capacity in the study area, but also enable expansion options for the next 10 years, while minimising social and environmental disturbance associated with maintenance requirements.

11.5 Effectiveness of current coastal protection and coastal infrastructure management

The effectiveness of current coastal protection and coastal infrastructure management was naturally assessed as part of the systematic coastal management option appraisal undertaken, where the Status Quo (current management activities) was compared to a number of alternatives and contrasted across multiple criteria that cover technical feasibility, economic viability and environmental and social desirability.

The preferred options were developed for each key management sectors and include potential cross sector dependencies. Improved management alternatives were identified for key sectors, namely Cape Peron and Safety Bay.

These preferred options have been individually defined to a level of detail that is sufficient to enable meaningful comparisons at this stage. Further development is therefore recommended to refine the design of the preferred options, including integration of key stakeholders' comments and suggestions to facilitate their implementation.

11.6 Identify locations for additional boat launching facilities in the study area

Several possible locations and configurations for additional boat launching facilities within the study area have been assessed, including:

- Consideration for boat launching facility development with and without major protective structures;
- Review of Point Peron Boat Launching Facilities, Carlisle Street Boat Ramp, Bent Street Boat Ramp and Donald Drive Boat Ramp;
- Systematic multi-criteria assessment of technical feasibility, economic viability and environmental and social desirability.

11.6.1 Informal or unprotected locations

Informal or unprotected boat launching were not found to be a satisfactory means to deliver additional boat launching facilities in the study area, as they would not be expected to meet performance criteria, due to an increased safety risk (e.g. weather exposure, navigational depth requirement), proximity with other users (beach goers, divers, wind/kite surfers) or environmental impact (e.g. seagrass, penguins).

11.6.2 New or significant upgrades

New or significant upgrades of boat launching facilities would incorporate major protective structures and meet expected performance criteria in terms of navigational safety. With a cost in the order of $10 million, these more formal and dedicated facilities would require large outlay of capital, and there is a risk of being potentially undesirable due to their environmental and social impact (e.g. direct impact on seagrass, perception of place).

Examples of such major brownfield upgrade included Carlisle Street or Donald Drive development. The trade-offs identified for these alternatives include:

- Donald Drive upgrade could be more desirable than Carlisle Street due to stakeholders' preferences and its better fit within the Master Plan.
- There is uncertainty regarding the coastal process impact of such facilities with potentially greater impact at Carlisle Street than Donald Drive.
- Donald Drive upgrade is anticipated to be costlier to develop than Carlisle Street due to the need to reclaim land partially.

For these reasons, but independently of the development cost, Donald Drive upgrade could be seen as a preferable option over Carlisle Street upgrade.

Although major brownfield development such as Carlisle Street or Donald Drive are not recommended at this stage, they certainly offer valuable options to consider in the future as demand pressure increases in a very constraint study area and they have the potential to support the CHRMAP long-term adaptive pathways 'protect' in this sector.

11.6.3 Exiting facilities expansion

Considering the multiple dimensions of the coastal study assessment, including the technical feasibility, economic viability and environmental and social desirability, as well as the alignment with the CHRMAP long-term adaptive pathways, less extensive upgrades of existing facilities which do not require additional protective structures are preferred over greenfield development or even major brownfield upgrades.

As a result, it is recommended to enable additional boat launching facilities in the study area, as follows:

- Cape Peron North - Spur Groyne adjacent to the Point Peron Boat Launching Facility be shifted northward as part of the committed upgrade works in 2020. This will enable additional boat ramps to be constructed to the north of the existing facilities.
- Safety Bay - Bent Street Boat Ramp and associated facilities be upgraded within 4-10 years subsequent to stabilising the head of the Tern Bank with a geotextile sand container groyne and seawall. Ongoing maintenance will be required at the newly created sand trap on Tern Bank Sandbar.

These recommended locations have sufficient capacity to accommodate further extension of existing facilities, subject to favourable public acceptance for the foreshore areas at Bent Street and a similar ratio of ramp and car/trailer park as present at Point Peron.

11.7 Identify most effective coastal management strategies

Potential improvements in management practices were identified as a result of the options appraisal process. A summary of the preferred options for each sector is provided below:

11.7.1 Sector 1 – Cape Peron North

The preferred option for Cape Peron North is *Option 3 – Shift Spur Groyne northward and added groyne.* This option involves the construction of a new geotextile sand container groyne upstream of the existing Spur Groyne and upgrade works to shift the existing Spur Groyne northward. The option facilitates independent coastal management operations from adjacent land owners, increases the sand trapping capacity of the Sand Trap and permits future expansion of Point Peron Boat Launching Facilities.

11.7.2 Sector 2 – Cape Peron South

The preferred option for Cape Peron South is *Option 4 – Nourishment - Slurry pump and permanent pipe.* This option involves the construction of approximately 500m length of permanent buried slurry pumping pipeline between the Point Peron Sand Trap and section of beach along the south of Cape Peron. The option is integral to the management of the Sand Trap and Point Peron Sand Stockpile within Sector 1, facilitating a systematic, economical and efficient approach to manage excess sand accrual in Sector 1 and the eroding beach profile in Sector 2.

11.7.3 Sector 3 – Shoalwater Bay North

The preferred option for Shoalwater Bay North is *Option 1 – Status quo.* This option involves the continuation of current management operations for the Sector. Specifically, continue the limited coastal management undertaken within the Sector.

11.7.4 Sector 4 – Shoalwater Bay South

The preferred option for Shoalwater Bay South is *Option 1 – Status quo.* This option involves the continuation of current management operations for the Sector. Specifically, the construction of the proposed seawall and associated sand nourishment works fronting the protective structure.

11.7.5 Sector 5 – Safety Bay

The preferred option for Safety Bay is *Option 2 – Stabilise Tern Bank with terminal groyne and sand trap management (local).* This option involves the construction of approximately 200m length of geotextile sand containers seawall at the head of Tern Bank and a 50m length of terminal geotextile sand container groyne running parallel to the current navigation channel. The option facilitates the upgrade of Bent Street Boat Ramp while improving the stability of the Tern Bank, allowing the Pond to remain open to support the City's strategic direction for the water body and associated amenities.

11.7.6 Sector 6 – Warnbro Sound

The preferred option for Warnbro Sound is *Option 1 – Status quo - Maintain Bent Street and Donald Drive facilities.* This option involves the continuation of current management operations for the Sector. Specifically, the maintenance of Donald Drive Boat Ramp as an informal over-sand launching facility.

These options systematically come-up ahead in the multi-criteria assessment. Sensitivity analysis has been undertaken on the ranking of options which randomises the weightings applied across all technical feasibility, economic viability and environmental and social desirability criteria, thus ensuring the robustness of the results.

The results of the options appraisal clearly established potential economic improvement in coastal management practices as compared to the status quo. The most effective options identified have estimated reductions in Net Present Value (at the 10 years horizon) of:

- $1.2 million for combining Sector 1 (Cape Peron North): *Option 3 – Shift Spur Groyne northward and added groyne* and Sector 2 (Cape Peron South): *Option 4 – Nourishment - Slurry pump and permanent pipe*.
- $1.0 million for Sector 5 (Safety Bay): *Option 2 – Stabilise Tern Bank with terminal groyne and sand trap management (local)*

It is recommended that these preferred options be further developed (including design, environmental planning, coordination with stakeholders and engagement with the community) to refine the design and facilitate their implementation.

11.8 Develop sound strategic approach to coastal management for the next 10 years to 2030

The Coastal Management Study developed a sound strategic approach to coastal management within the study area for the next 10 years to 2030. The Study benefited from being underpinned by a structured approach to define and appraise options, and focused on a holistic view of coastal management issues and objectives within the study area. As a result, the preferred options support the Safety Bay and Shoalwater Foreshore Master Plan vision for the area and align with the CHRMAP long-term adaptive pathways.

Notably, the purpose of the new coastal structures incorporated in the preferred options (both in Cape Peron and Safety Bay) is to support strategic coastal management operations within the 10-year planning horizon, including:

- Reducing coastal vulnerability;
- Improving the economics of coastal management activities; and
- Maintaining and enhancing amenities and coastal values.

Importantly, the preferred options:

- Do not hinder the City's longer-term strategy beyond 2030 as adopted in the CHRMAP;
- Support the longer-term protection scheme required to accommodate the natural long-term erosion and inundation risks highlighted in the CHRMAP; and
- Align with the City's strategic vision defined in the Safety Bay and Shoalwater Foreshore Master Plan to develop the Pond as a focus area for events.

It is recommended that the Coastal Management Study be reviewed and updated in 5 years following the development of the preferred options, to incorporate newly available information and meaningful changes that take place in the study area, as well as updating the leading issues and objectives.

11.9 Further studies

A number of further studies have been identified which are necessary to assist in the City in refining coastal management initiatives. These are outlined below:

- Developing the design of the preferred options, incorporating key stakeholders' comments and suggestions
- Undertake detailed shoreline dynamic studies of Tern Bank Sandbar, including:
  - response to the existence and non-existence of the offshore sand feed;
  - response to ambient and extreme events with and without protective structures; and
  - response to ambient and extreme events for various sand placement scenario.
- Undertake water quality study of the Pond, including modelling and management plans

12 References

Rockingham Coastal Management Study – Literature Review (Cardno, 2019) and associated references detailed in Section 5.0 (refer Appendix A);

Rockingham Coastal Management Study – Stakeholder Engagement Report (Cardno, 2019) (refer Appendix B).

Coastal Sediment Cells for the Vlamingh Region between Cape Naturaliste and Moore River, Western Australia (2015)

State Planning Policy 2.6 State Coastal Planning Policy (2013) and Guidelines (2013)

Sea Level Change in Western Australia Application to Coastal Planning (2010)

Perth Recreational Boating Facilities Study – Planning for Future Needs 2007 – 2025 Technical Report No.4444;

Draft Coastal Hazard Risk Management and Adaptation Plan (City of Rockingham, 2019)

Coastal Hazard Risk Management and Adaptation Plan – Technical Assessment Report (Cardno, 2018).

Draft Safety Bay and Shoalwater Foreshore Master Plan (City of Rockingham, 2019)

Safety Bay/Shoalwater Coastal Management Study

APPENDIX A

LITERATURE REVIEW

Safety Bay/Shoalwater Coastal Management Study

APPENDIX B

STAKEHOLDER CONSULTATION REPORT

About Cardno

Cardno is a professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

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